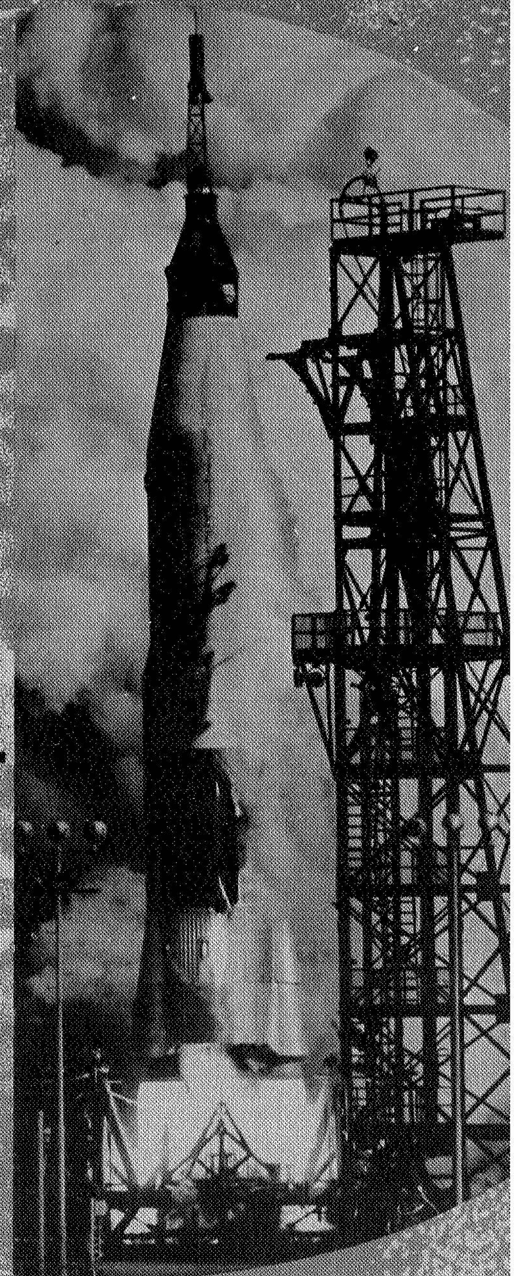
N62-17182

Sixth SEMIANNUAL REPORT TO CONGRESS



uly 1—December 31, 1961

NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

To the Congress of the United States:

Pursuant to the provisions of the National Aeronautics and Space Act of 1958, as amended, I transmit herewith a report on the projects and progress of the National Aeronautics and Space Administration for the period of July 1, 1961 through December 31, 1961. This is the sixth of these reports since the passage of the legislation establishing that Agency.

This report reveals evidence of the constructive impact of the decision, made earlier in the year and supported strongly by the Congress, to accelerate our space efforts. The accomplishments summarized and detailed in this document constitute an important part of the national program, in which the National Aeronautics and Space Administration, as well as other Government agencies, cooperate.

John F. Kennedy

The White House,
September 27, 1962.

N62 - 17182

SIXTH SEMIANNUAL REPORT TO CONGRESS

JULY 1 THROUGH DECEMBER 31, 1961

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price $1.00

September 7, 1962.

THE PRESIDENT,
The White House.

Dear Mr. President: This Sixth Semiannual Report of the National Aeronautics and Space Administration, covering the period July 1 through December 31, 1961, is submitted to you for transmittal to the Congress in accordance with Section 206(a) of the National Aeronautics and Space Act of 1958. Part I of this report summarizes NASA accomplishments and progress; part II discusses them in detail.

The progress recorded during this period gives assurance that the national space program is advancing as planned, and will continue to enhance the Nation's prestige and benefit its economy.

Respectfully,

JAMES E. WEBB
Administrator.

CONTENTS

PART I

PART II

APPENDIXES

ILLUSTRATIONS

TABLES

Part I

Summary

During the period covered by this report, NASA programs made significant progress in the all-out drive to achieve the space goals and objectives of this Nation.

The achievements ranged from Project Mercury's second manned suborbital flight to TIROS III's discovery of Hurricane Esther; from the agreement between NASA and AT&T to develop and test an active-repeater communications satellite (Telstar) to the inauguration of the two-man spacecraft Project Gemini; and from dedicating the deep space tracking facility in Johannesburg to conducting the first International Meteorological Satellite Workshop.

The benefits derived from these and other achievements represent gains ranging from new scientific knowledge to high performance space systems.

The continuing goals of the National Aeronautics and Space Administration as set forth by the President and the Congress include the following:

a. Manned lunar exploration within this decade;

b. Unmanned lunar and planetary exploration programs;

c. Development and application of passive and active communication and meteorological satellites;

d. Development of launch vehicles and propulsion systems necessary for both exploration and application programs;

e. Extended aeronautical research for both civil and military uses;

f. Expansion of the entire body of knowledge relating to space and man's possible adaptability to it; and

g. Broadened international cooperation in space research.

Following is a summary of the progress NASA made toward the achievement of these goals and objectives.

Manned Lunar Exploration

In carrying out the express will of the President and the Congress, NASA is giving highest priority to the projects leading to manned exploration of the moon. Plans call for reaching this goal by the late sixties. The projects directly involved are Mercury, Gemini, and Apollo.

Project Mercury, organized in October 1958, represents the first phase in this effort. Its purposes are to orbit a manned capsule, to investigate man's reactions to space flight, and to recover both man and capsule. Such experience is a vital prerequisite to moon landings.

Within the period, Astronaut Virgil I. Grissom successfully completed the second U.S. manned suborbital flight (first was completed by Astronaut Alan B. Shepherd, Jr., on May 5, 1961). In addition, two Mercury capsules were orbited and recovered; one of these was unoccupied, while the other contained the chimpanzee, Enos. Encouraged by the data from these experiments, NASA prepared for the first United States manned orbital flight and named Astronaut John H. Glenn, Jr., as pilot. (Glenn's historic flight will be covered in the report for January 1–June 30, 1962.)

Following early Mercury tests, NASA determined that an intermediate manned orbital project was necessary. The project, called Gemini, will conduct advanced earth orbit experiments. A two-passenger capsule, configured like Mercury but 50 percent larger, Gemini will perform sustained missions and will test the feasibility of rendezvous and docking.

Apollo, the project geared to placing American explorers on the moon's surface and returning them to earth, is the terminal phase of the first manned lunar landing objective. The Apollo spacecraft will carry a three-man crew for orbits around the moon and subsequently for lunar landing and exploration.

During this period, NASA held a series of conferences with potential Apollo project contractors, solicited design and development proposals from eligible ones, and selected the prime contractor to design and build the spacecraft and the second unit. In addition, NASA selected the guidance-navigation system contractor, expanded facilities for launch, and awarded a contract to study the technical feasibility of manned space stations as a means of accelerating the lunar program.

Concurrent with the lunar exploration program, NASA improved tracking and data acquisition networks. It completed the deep space instrumentation facility in Africa, readied the Mercury network for manned orbital flight, completed construction of Minitrack stations in Alaska and Newfoundland, completed one 85-foot tracking antenna and chose the site for another. NASA also chose a contractor to study the feasibility of 200–250 foot diameter antennas. All networks will support manned spacecraft, satellites, and planetary exploration vehicles.

Unmanned Lunar and Planetary Exploration Programs

During the period, NASA gained significant additional knowledge of the earth's space environment and the relationship between the earth and the sun. This information was derived from two geophysical satellites, a geophysical probe, and 28 sounding rockets which the Agency launched.

Explorer XII, an energetic particles satellite, transmitted data that changed the accepted image of the Van Allen radiation region, revealed a definite outer edge to the earth's magnetic field, and gave new evidence of the effect of solar events upon the earth. Explorer XII provided more useful data than did all previous satellites combined. During the 112-day life span it sent back over 3 billion bits of useful information.

The information from the Explorer XII experiment directly benefits the manned space flight program, particularly with regard to the areas of radiation to be encountered. It is also being used in designing solar powered satellites—one of its experiments compared the protection varying thicknesses of glass coating afforded solar cells against deterioration caused by radiation.

An electron density profile probe relayed information about the ionosphere which should contribute to improved radio communication and lead to greater accuracy in ground tracking of spacecraft.

Scientific information from other satellites of the Explorer series included information on the density of the atmosphere and its relationship to sun spots and on theories relating to the origin and evolution of the universe. All the information indicated the complexity of our environment and the kind of satellites required for further observation and study.

Satellites under development or being readied for launching include some to study the composition of the upper atmosphere, others to study the ionosphere, a geophysical observatory able to carry as many as 50 different experiments, and a solar observatory designed for intensive studies of the sun and its phenomena. NASA is also planning an astronomical observatory to provide knowledge about the solar system, the stars, and the composition of space. Data will be collected and sent back by about a thousand pounds of scientific equipment.

The data collected by NASA satellites and sounding rockets have increased knowledge of the radiation hazard presented to manned space flights by solar flares. These studies also returned valuable data on temperatures, velocities, directions, and densities of winds of the upper atmosphere. They relate directly to weather research, high altitude aircraft, and rocket launching. Rockets have also been used to give NASA information on the X-rays thrown out by the sun. Their data are unique because they carry X-ray photometers above the earth's atmosphere.

Sounding rocket experiments have given increased understanding of the region of the atmosphere called the ionosphere. This knowledge can be applied to radio communications and tracking of spacecraft and is a necessary type of research for our manned space flight program.

NASA is developing unmanned instrumented spacecraft to precede man to the moon and to the other planets. The value of such craft lies in their ability to provide vital information about the unfamiliar environments of the moon or other planets, to help determine favorable landing areas, and to proof-test many of the systems which will later be used for manned flight. In addition, such craft could accompany manned expeditions to serve as supply or reconnaissance vehicles.

NASA plans to use instrumented probes in its broad lunar and interplanetary research program to seek answers to such questions as the origin of the solar system, the possibility of life on other planets, and the nature of space.

NASA launched two Ranger spacecraft which returned much valuable data and permitted researchers to check out systems even though they did not achieve the intended orbit. Ranger I gathered and transmitted information on radiation, cosmic dust, and magnetic fields, which will be used in readying subsequent Rangers. The Ranger spacecraft support the accelerated manned lunar landing program.

Surveyor is another instrumented craft being developed by NASA for a controlled landing on the moon. It will carry instruments to gather, analyze, and transmit information about the surface and subsurface of the moon. The first Surveyor spacecraft are scheduled for launch beginning in 1964.

Another program to acquire scientific information on the atmosphere, surface, and magnetic fields of Mars and Venus is called Mariner. In this program, it also is possible that information relating to the existence of life on these planets will be collected. Assembly and final testing of two Mariner "R" spacecraft moved toward the scheduled launching in the summer of 1962. The primary purpose of the earliest Mariner flights will be to determine the surface temperature of Venus and to gather information on interplanetary space.

NASA is also considering a follow-on to the first Mariner. This craft, to be designated Mariner "B," would have a capsule capable of landing instruments on Mars or Venus to transmit data about the surface and atmosphere.

In the concept stage is a series of advanced spacecraft called Voyager. These heavily instrumented spacecraft would be able to go into orbit about a target planet. They would have high resolution television cameras and instruments to collect data about the atmosphere, magnetic fields, and radiation belts of the planet. Voyager might also carry an instrumented capsule to be sent to the planet's surface to relay information. One of its tasks would be to pick up and analyze soil samples to determine whether chemicals are present which would support life.

Development and Application of Meteorological and Communications Satellites

NASA made substantial progress in developing operational meteorological and communications satellites. When developed, these satellites will have a profound effect on our daily lives and our economy. Meteorological satellites will improve weather forecasting and thus prevent losses of life and property. Communications satellites present an enormous potential for increasing our long distance communications resources.

During the period, NASA launched the third of its successful series of TIROS experimental weather satellites. TIROS III, launched July 12, not only discovered and provided the first data on Hurricane Esther; it also transmitted timely storm-revealing pictures of cloud systems (as well as infra-red data) from vast areas of the earth. From cloud-cover data furnished by this satellite, the U.S. Weather Bureau was able to provide national and foreign weather stations with valuable weather data and to warn areas threatened by dangerous storms.

TIROS IV was nearing completion at the end of the period. And work progressed on more advanced weather satellites: Nimbus and Aeros. Nimbus will be more nearly operational than TIROS III. Aeros, because of its more or less "stationary" position in relation to the earth, will maintain constant surveillance of weather systems in the tropical and temperate latitudes.

These meteorological satellites mean that a global system of accurate long-range and short-range weather predictions is in the offing.

Research, development, and testing continued on two systems of communications satellites—passive (reflecting transmissions received) and active (retransmitting received signals).

Preparations were almost completed for suborbital testing of a passive satellite larger and more rigid than the 100-foot Echo I (in orbit since August 1960), and studies continued on Project Rebound, designed to place three advanced Echo satellites in orbits from a single launch.

Developmental work progressed on two active satellites: Relay and Syncom. Relay will be launched into an elliptical orbit. Syncom will be placed in a 24-hour orbit; that is, it will make an orbit each 24 hours, its speed exactly coinciding with the earth's rotation.

During the period, NASA cooperated with the American Telephone and Telegraph Company on the Telstar project. NASA assisted in analyzing and processing data for research and development on the spacecraft and ground systems. It also established environmental test specifications for the spacecraft and arranged to supply the launch vehicle.

Communications satellites provide more economic means than new submarine cables for meeting the greatly increased demand for trans-oceanic services; they make worldwide television foreseeable; and they make possible new forms for global communications, such as closed circuit TV on an international basis.

Launch Vehicles and Propulsion Systems

In a broad sense, the manned spacecraft, the unmanned exploratory vehicles, and the experimental satellites represent the "pay-off" stage of NASA's efforts. Their effectiveness in achieving design and program goals, however, is directly related to the effectiveness of their launch vehicles.

For this reason, NASA continues to improve the boosters and launch vehicles now being used and to accelerate development of those needed during the latter half of this decade. The former group includes Scout, Delta, Thor-Agena, and Atlas-Agena. The necessary ones for the months and years ahead include Titan II, Centaur, Saturn C–1, the Advanced Saturn (C–5), and the Nova concept.

With the boosters and launch vehicles now in use, NASA made these improvements: A new solid propellant for Scout enables it to orbit a 240-pound satellite (heretofore its limit has been 150 pounds). Delta's reliability made it feasible to extend the life of this workhorse booster beyond the planned cutoff time of 1961; the manufacturer received a contract to fabricate 14 additional vehicles. NASA is coupling the restartable Agena B as an upper stage with the Thor and Atlas; the Thor-Agena B was selected as the vehicle for launching scientific and other applications satellites requiring polar (north to south) orbits. Atlas-Agena B was chosen for the advanced communication, meteorological, and scientific satellites (Rebound, Orbiting Astronomical Observatory, and others).

Beyond these, NASA chose the Air Force-developed Titan II as the launch vehicle for Project Gemini. This choice represents a means of having the required amount of thrust without a costly and time-consuming development program for a new booster. Captive firing tests were in progress during this period. A significant advantage of Titan II over earlier boosters: it uses a storable liquid-fuel and thus can be fueled well ahead of launch time.

With the Atlas-Centaur, the launch vehicle planned to have a major unmanned lunar and interplanetary role, NASA concentrated its efforts on the Centaur engines. (Centaur is the second stage of the launch vehicle.) The high-performance engine (designated RL–10) underwent 20 successful ground firings and passed its preliminary flight rating test on November 20, 1961.

The first stage (S–1) of Saturn C–1, designated for early Apollo missions, gave a near-perfect performance in its first flight on October 27. Takeoff thrust was 1.3 million pounds. This test supported the use of engine clusters for the Advanced Saturn and the Nova launch vehicles. NASA also ground tested the second S–1 and began assembly of the third. The newly acquired Michoud Plant, near New Orleans, will be used by the contractor to build operational copies of the S–1.

The Advanced Saturn, representing the next step up the high-thrust ladder, will be a versatile, flexible launch vehicle for multiple uses in the Apollo program. During this reporting period, research and development work on the first stage advanced sufficiently to permit NASA to negotiate with a specific contractor to design, develop, and produce it. Development work was started on the second stage, and a contractor was selected to modify the third stage.

The most powerful launch vehicle yet envisioned is the Nova; NASA settled on the major features of Nova during this period: a first stage of eight 1.5 million-pound-thrust engines; a second stage cluster of four engines with a total thrust of 4 million pounds; and a third stage similar to that of the Advanced Saturn. Nova will be able to launch 185-ton orbiting space stations, 75-ton lunar spacecraft, or 50-ton interplanetary space ships.

In addition to its work with launch vehicles, NASA continued to attack propulsion problems on a broad front. It tested prototypes of low-thrust, long-running electric engines; it contracted for initial work in developing the first nuclear rocket engine as an outgrowth of the Kiwi phase of Project Rover; and it advanced the work being done with both liquid and solid chemical propellants.

Aeronautical Research

NASA's aeronautical research programs continued to supply data valuable in the development of spacecraft and aircraft. The seven X–15 flights during the period added significantly to man's knowledge of the stresses of space flight and of the ability of materials to withstand such stresses and heating, and showed that man could operate such aircraft under conditions of high acceleration and weightlessness. These flights also demonstrated the value of having a man aboard the space vehicle to exercise his judgment and to take over if automatic systems malfunction.

The X–15 research program has also added vital data on reentry to the earth's atmosphere and on manned control of large rockets during the powered phase of a spacecraft's flight.

The data derived from the X–15 research program has been applied to the Project Mercury suborbital flights and to design of the Apollo space vehicle. The information is also being used in studies of supersonic transports which NASA is conducting for the Federal Aviation Agency.

Knowledge gained from the X–15 program has also been useful in saving time in the development of the rocket-propelled X–20 (Dyna-Soar) glider being developed by the Air Force with NASA technical support.

The data gained on aerodynamics, the abilities of materials to withstand the stresses of space flight, aerodynamic heating, control and other related topics during the research on the X–15 are all applicable to the development program for the supersonic transport.

The Agency also continued to conduct research on vertical takeoff and landing aircraft, which have potential use in both military and civilian applications. Several models of VTOL aircraft are under study in wind tunnel tests and others are in design stages. The data accumulated on these aircraft is being used to speed up their development, thus saving airport space and making it possible to locate airports closer to metropolitan areas.

One of NASA's important responsibilities in aeronautical research is to conduct investigations which will lead to increased safety of operation of commercial aircraft. NASA has been conducting extensive tests in conjunction with the Federal Aviation Agency on the effects of runway slush on jet operation. The research indicated that the effect of slush on jets was twice as great as had previously been thought. These findings led to a ruling by the Federal Aviation Agency that operations be halted when runway slush reached a depth of over half an inch.

Life Sciences

In the life sciences, NASA began a number of investigations related to conditions expected to be encountered in space travel. Radiation is one of the foremost hazards of space flight. Project BIOS is the

NASA program particularly concerned with this subject. Its space probes study the effects of radiation (and of weightlessness) on living organisms. In November, an Argo D–8 rocket carried aloft experiments to study the effects of the radioactivity of the Van Allen belts on algae, bacteria, human blood cells, and of barley seed.

NASA is conducting research into life detection systems which could be carried by instrumented spacecraft (Mariner or Voyager) designed for reconnaissance of Mars and Venus. One such device is a radioisotope biochemical probe to detect the presence of microbes on Mars. It is small, sensitive, and reliable but rugged enough to withstand lunar or planetary landings.

Infrared spectroscopes carried in high-altitude balloons or planetary orbiting spacecraft would be able to detect life-related compounds and to study and analyze a planet's atmosphere. NASA plans to include such a spectroscope on the Mariner spacecraft. An infrared spectroscope to be carried by a balloon above 80,000 feet is in the design stage at the University of California. It will be capable of being automatically trained and focused to examine the Martian surfaces for evidence of organic compounds.

NASA-supported research on the ability of microorganisms to withstand the conditions of space may answer questions about extraterrestrial life and influence future planetary probes. One of the findings was that the spores of several bacteria were able to survive for 5 days in a hard vacuum typical of space. This demonstrated that the space vacuum can't be relied on to sterilize spacecraft. Another finding, derived from research into simulating the atmosphere of Mars, was that several species of earth's bacteria could conceivably exist on Mars. Additional research has isolated from the salt flats of San Francisco Bay microbes capable of surviving and reproducing in the absence of moisture. These bacteria could possibly exist on Mars.

In seeking to determine whether life exists on other planets, scientists must be sure that life forms that may be found have not been introduced by a space vehicle. To preclude this possibility, NASA has developed sterilization techniques using liquid and gaseous sterilants to decontaminate Ranger A–3—the first planned impact vehicle. Decontamination requirements for the compartments and subcompartments of the Surveyor spacecraft have been established, and a decontamination system for the entire vehicle is to be completed early in 1962.

Broadened International Cooperation in Space Research

The National Aeronautics and Space Act of 1958 directs NASA to cooperate with other nations in aeronautics and space activities. As a result of this policy, the Agency engaged in various international activities during the period.

The activities included aid extended to foreign nationals to study and receive training in the space sciences. Scientists from 13 countries began or continued research under postdoctoral grants at the Goddard Institute of Space Studies: 7 fellows from 5 countries enrolled at 6 U.S. universities to study under NASA International Fellowships; and 48 tracking station personnel from 13 countries received training in space research at Goddard Space Flight Center.

A program of international cooperation resulted from the launching of the TIROS III meteorological satellite. Twenty-nine countries conducted ground observations when the satellite was over their territories, and 39 representatives of 27 nations participated in the International Meteorological Satellite Workshop. Cloud analyses and storm warnings based on TIROS III data were transmitted to foreign countries.

The West German Post Office and the Brazilian Department of Posts and Telegraphic Communications agreed to provide terminals to be used with experimental communications satellite projects. The British General Post Office and the French Center for Telecommunications Studies continued construction of ground stations for these projects.

NASA cooperated with many foreign countries in studies of the upper atmosphere. It conducted sounding rocket experiments with Australia, Canada, and Italy. It agreed to conduct a joint upper-atmosphere sounding rocket program with the Pakistan Upper Atmosphere and Space Research Committee in 1962. Under this program, Pakistanis are being trained at the Goddard Space Flight Center and at Wallops Station. In a similar cooperative activity, Wallops Station trained Swedish technical personnel and supplied five rockets in support of the Swedish Space Committee's program to conduct studies of noctilucent clouds in the upper atmosphere. Wallops Station also prepared to launch a Japanese resonance probe and a Goddard Space Flight Center Langmuir probe combined into a single payload on a Nike-Cajun rocket.

The S-51 satellite, a joint effort of the United Kingdom and the United States, neared completion. (The first international satellite, it was launched April 26, 1962, from Cape Canaveral by a NASA-supplied Delta rocket. Designated Ariel, it is now collecting data from the ionosphere.) Preliminary plans were developed for a second British-U.S. satellite of the same type. In a similar venture, NASA continued working with the Canadians in preparing the launching of the Canadian-developed Alouette topside sounder satellite, which will also be used to study the structure of the ionosphere.

Finally, NASA's Office of International Programs assisted the Department of State and the United States Delegation to the United Nations in formulating a UN policy on outer space.

Even as this report is being prepared, NASA advances continue. Major accomplishments since the termination date of this report include the three-orbit flights of Astronauts Glenn and Carpenter; successful launches of TIROS IV and TIROS V; the lunar impact of Ranger IV; the successful launch and test of Telstar; and the reorientation of the Apollo project, providing for a two-man excursion vehicle to explore the lunar surface while the third crew member orbits the moon in the Apollo spacecraft.

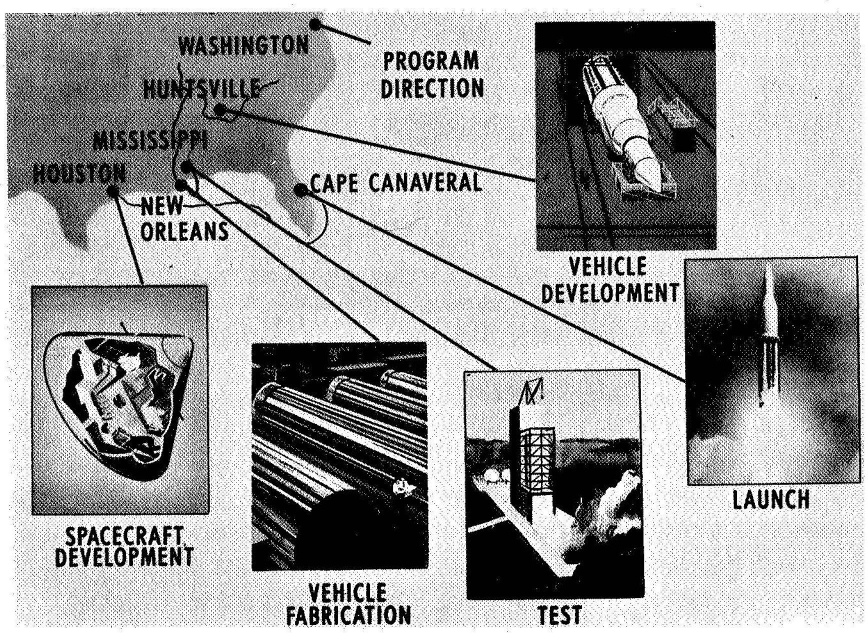
Individual chapters of this report contain the details of NASA accomplishments of the July 1–December 31, 1961 period. Those achieved after January 1, 1962, will be discussed in later reports.

Part II

Manned Space Flight

Mercury, Gemini, and Apollo Move Ahead

During this reporting period, Project Mercury moved toward its final phase. Astronaut Virgil I. Grissom duplicated Alan B. Shepard's May 5 suborbital flight; an unmanned Mercury capsule, launched by an Atlas booster, orbited the earth and was recovered; and a Mercury Capsule, carrying a chimpanzee, "Enos," made two orbits and was recovered from the Atlantic Ocean.

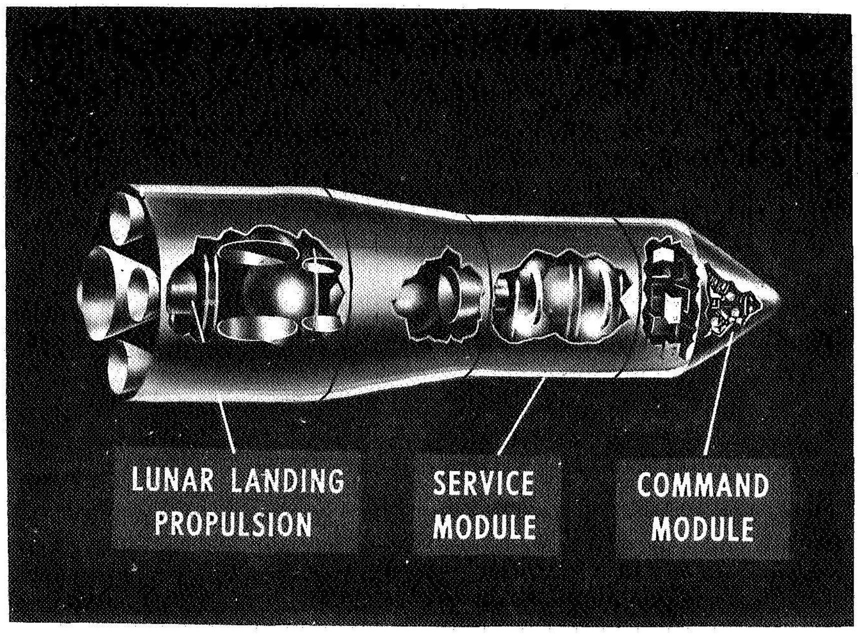


Manned space flight—major activities.

The NASA also initiated Project Gemini as a follow-on to Project Mercury. The Gemini spacecraft was planned as a Mercury-type capsule designed to accommodate two astronauts and to travel in space for a week or more. It would also be able to test rendezvous techniques and thus provide experience and training for the Apollo project.

Gemini was viewed as a preparatory step in the development of manned space vehicles leading to the larger, lunar-landing spacecraft of Project Apollo.

At the same time, progress was made in accelerating work on Project Apollo. NASA awarded five contracts for the construction of the three-man Apollo spacecraft, its Saturn booster, and the associated navigation systems. In addition, the Atlantic Missile Range, Cape Canaveral, was selected as the Apollo launch area and steps were



Artist's conception of the Apollo spacecraft.

taken to enlarge its complex. Further, NASA selected three new locations for work on the manned lunar landing program: The Manned Spacecraft Center, Houston, Tex.; the Michoud Plant, New Orleans. La.; and the Mississippi Test Facility, in southwest Mississippi.

Project Mercury

Second Suborbital Flight (MR-4)

The second successful manned suborbital flight in Project Mercury was achieved on July 21, 1961, with astronaut Virgil I. Grissom as pilot of the spacecraft "Liberty Bell 7." Objectives of the flight were to confirm data obtained during the first suborbital flight and to further test the Mercury capsule and its life-support and telemetry systems.

Flight Details.—The MR–4 flight, twice delayed by unfavorable weather, began with lift off from Cape Canaveral at 7:20 a.m. e.s.t. The capsule reached an altitude of 118 miles and traveled 303 miles down the Atlantic Missile Range, landing in the planned recovery area at 7:35. In the course of the trip, Grissom experienced 5 minutes of weightlessness. During the flight, he used the large window of the capsule to observe the earth, sky, and stars in the blackness of space. He visually confirmed such flight sequences as booster separation, jettison of retrorocket, and drogue and main parachute openings.

Grissom successfully maintained attitude control with the manual control systems. He also manually triggered ignition of the retrorockets from the capsule and exercised manual capsule-attitude control during the 22-second rocket firing which slowed the capsule for reentry.

Capsule Landed Successfully.—During descent and atmospheric entry, the capsule underwent a maximum deceleration force of 11 g's. Grissom withstood the g forces without difficulty, making several voice communications during this period.

The capsule landed near the predicted location northeast of Grand Bahama Island, within sight of the recovery ships. Astronaut Grissom delayed leaving the capsule until he had recorded certain data, then informed the pilot of the Marine helicopter that he was ready for a normal recovery or hookup procedure.

Liberty Bell 7 Lost.—However, before the helicopter could hook onto the capsule, the escape hatch was separated from the side of the capsule by a premature firing of its explosive bolts. Water poured in as Grissom pulled himself from the capsule and swam away. After 4 minutes in the water, he was recovered by a second helicopter and flown to the carrier U.S.S. *Randolph.*

Efforts to rescue the capsule failed; it sank in the ocean where the water was too deep for salvage operations. The cause of the premature actuation of the hatch's explosive bolts was not determined.

Mercury-Redstone Program Concluded

Despite the loss of the capsule, the MR–4 test was highly successful, clearly demonstrating that the Mercury spacecraft was fully qualified for the orbital mission. However, the Redstone booster, developing 78,000 pounds of liftoff thrust, was not intended for earth orbital missions. For this purpose, NASA had selected the 360,000-pound-thrust Atlas booster.

Mercury Orbital Flights

Unmanned Mercury-Atlas (MA-4) Makes Single Orbit.—On September 13, an unmanned Mercury-Atlas (MA–4) was launched

656299 O—62——3

from Cape Canaveral into an earth orbit. The capsule, an early version without explosive hatch or impact bag, made one complete trip around the earth, was brought back, and landed in the Atlantic Ocean about 160 miles east of Bermuda. It was recovered by the destroyer *U.S.S. Decatur*.

The MA–4 capsule contained a mechanical device to simulate human respiration, voice tapes to communicate with the tracking stations, and a fully operational automatic attitude control system.

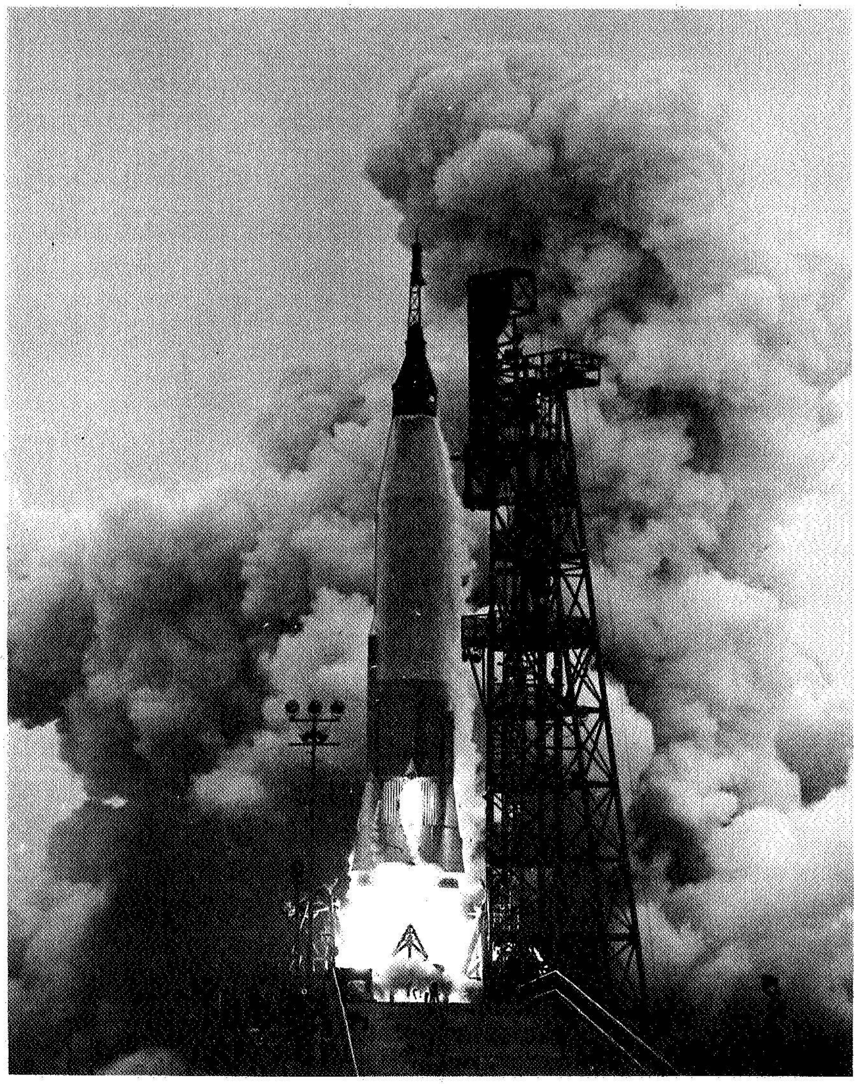
Mission Succeeds.—The flight was highly successful, qualifying the life support systems, the worldwide Mercury tracking network, and the spacecraft controls for manned flight. Voice transmissions between the unmanned capsule and the ground stations were satisfactory, and the tracking network stations sent data to Goddard Space Flight Center computers swiftly and accurately for relay to the control center at Cape Canaveral. The capsule's control systems operated as programed, automatically firing the braking rockets and deploying the parachutes to land the spacecraft safely.

Two minor faults developed during the flight. One problem arose when an inverter (a device that changes direct current to alternating current) failed during launch. However, a standby inverter was automatically switched into the circuit. An astronaut would have been able to correct this malfunction promptly. The second difficulty was a too rapid use of the capsule's main oxygen supply. This resulted from vibrations which moved an emergency oxygen handle to the "on" position, thus releasing oxygen at a higher than normal rate during the orbit. Again, an astronaut would have been able to eliminate this problem easily.

MA–5 Carries Chimpanzee on Two-Orbit Flight

Final Test of Mercury Systems.—Despite the success of the MA–4 flight, NASA scheduled one more test of the Mercury capsule before orbiting a manned spacecraft. To simulate the conditions of manned flight as closely as possible, it was decided to send a chimpanzee on a three-orbit trip in a Mercury capsule.

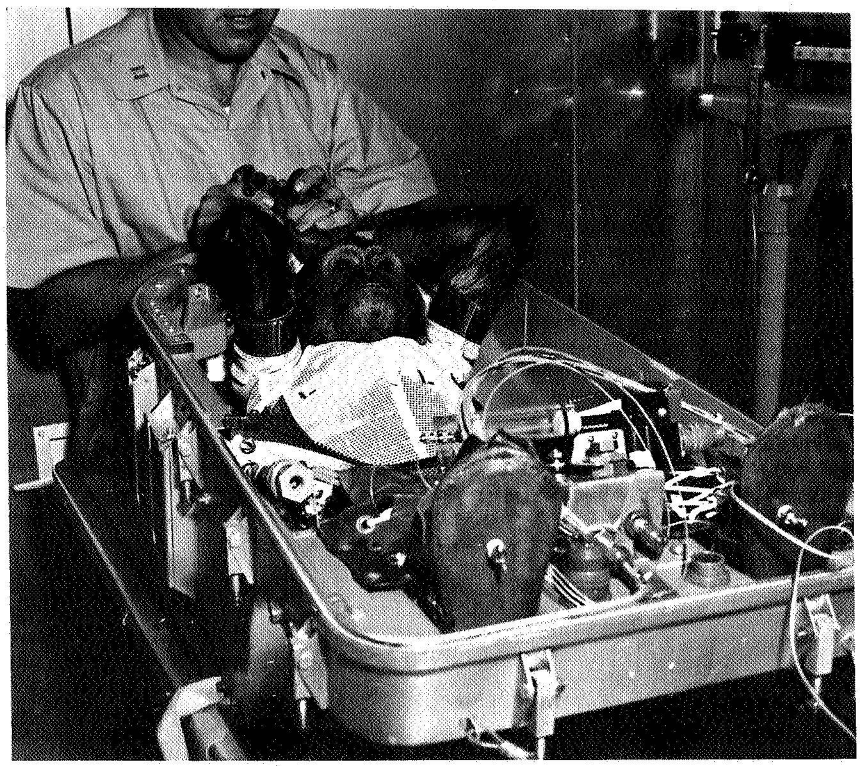
Launched from Cape Canaveral.—Preparations for the MA–5 flight followed precisely the routine set for manned flight. The chimpanzee—Enos, a 5½-year-old, 37½-pound male, trained by Air Force specialists—began the day at 2:28 a.m. e.s.t., November 29, when he was dressed in a special space suit and zippered onto his space couch. He was next transported to the launch pad and secured in the Mercury capsule about 4:15 a.m. The launching, scheduled for 7:30 but delayed by trouble in the telemetry system, took place at 10:07.



Atlas launches primate-carrying Mercury capsule.

Flight Terminated After Two Orbits.—During the first orbit, all spacecraft systems functioned properly, and Enos carried out his four main tasks. The chimpanzee had a series of levers to move in sequence with flashing colored lights. These tests were designed to indicate any effects weightlessness and the stresses of space flight might have on the animal's perception and physical reactions.

During the second orbit, the capsule's roll control system began to malfunction, and the stabilization jets took over. These jets, designed



Enos relaxes before his Mercury flight.

to make major corrections during descent, consume large quantities of hydrogen peroxide in exercising control. If this fuel were used excessively during the orbital flight period, the jets might not be effective during descent, thus endangering the outcome of the flight. In addition, the capsule's cooling system was letting the cabin and the electrical system become too warm. Consequently, Mercury Control Center decided to terminate the mission.

Capsule Landed and Recovered.—A ground command transmitted by the Point Arguello, Calif., tracking station fired the capsule's retro-rockets as it approached the end of its second orbit. The capsule made a normal reentry, decelerating within 3 minutes from a speed of 17,500 m.p.h. to 1,350 m.p.h. At 21,000 feet the drogue parachute opened, followed by the main chute at 10,000 feet. The landing occurred at about 1:28 p.m. in the planned recovery area. The capsule and the chimpanzee were recovered by the destroyer U.S.S. *Stormes* and taken to Bermuda. Enos was flown to Cape Canaveral, where examination disclosed no apparent ill effects from the flight.

Mercury-Atlas Ready for Manned Flight.—The test objectives of the MA–5 flight were substantially accomplished. A detailed study of the spacecraft, booster, and tracking network operation indicated that the Mercury-Atlas system was ready for manned orbital flight. The mechanical problems that developed during the second orbit would have been corrected if a human astronaut had been aboard.

At the conclusion of the successful MA–5 flight, NASA announced that astronaut John H. Glenn, Jr., had been selected as pilot for the first manned Mercury flight—scheduled for early 1962.

Project Gemini

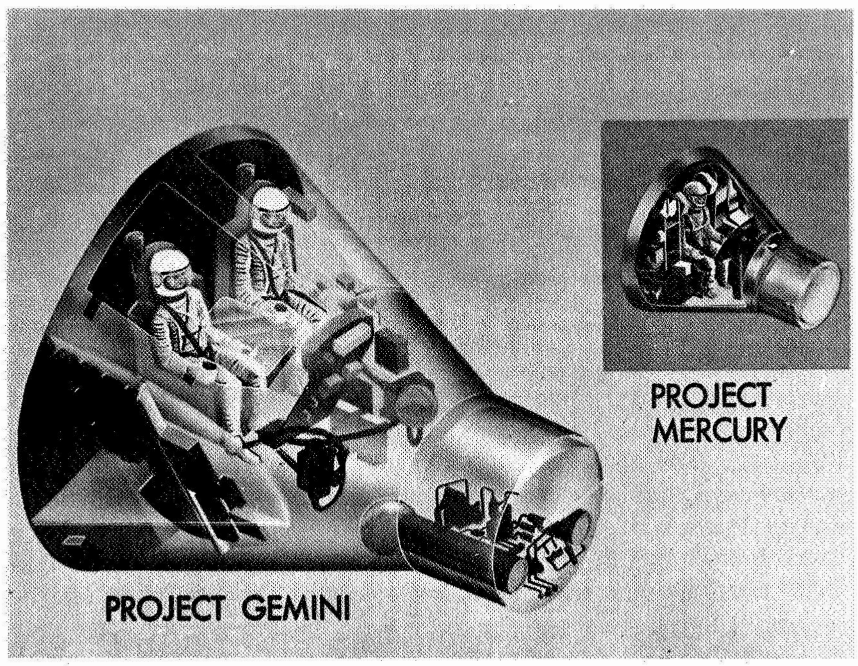
Project Mercury plans called for the development of a spacecraft capable of carrying one astronaut in earth orbit for about 24 hours at the most. The manned lunar trip of Project Apollo would require much longer flight periods. For practical reasons, NASA decided to extend Project Mercury to develop a two-man spacecraft capable of earth orbital flights of a week or more. This craft would provide pilot training and experience for circumlunar and lunar landing flights, bridging the true interval between the one-man Mercury flight and projected Apollo tests.

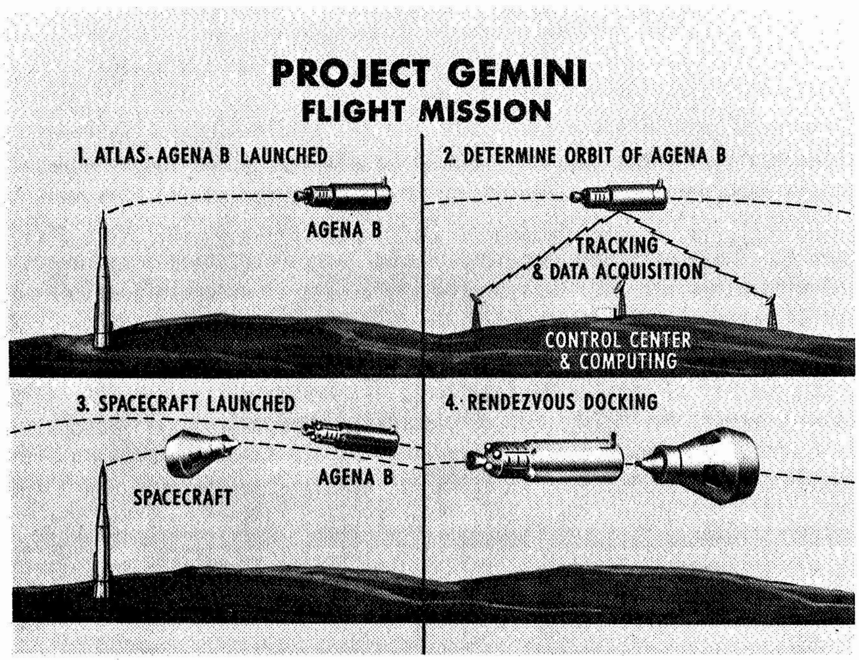
Gemini Planned as Mercury Follow-on.—NASA planned Project Gemini as the extension of the Mercury project to develop a new two-man Mercury-type capsule. It would have the same general shape as Mercury but would be larger and more complex. Cabin space would be 50 percent greater and weight two or three times that of the current 2,000-pound Mercury capsule.

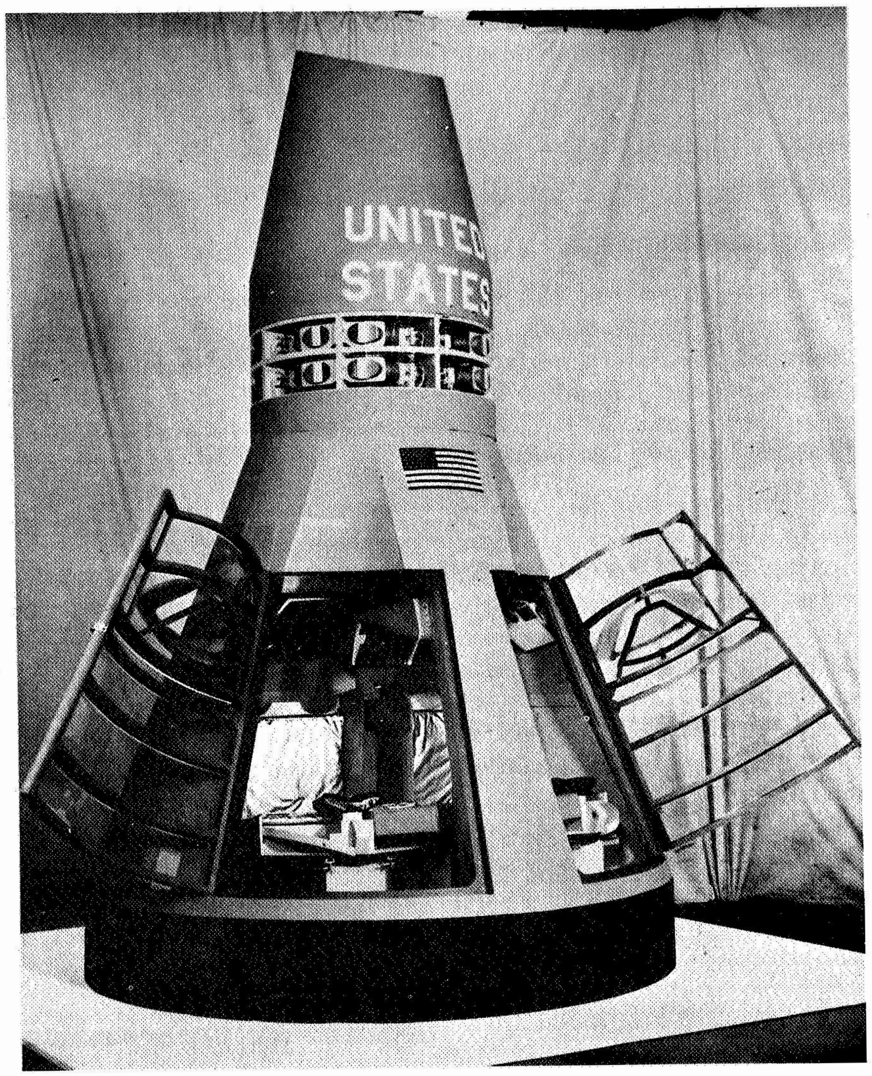
Gemini would have generally the same life-support systems as Mercury but their capacity would be greater. The installation of many subsystems, now located in the Mercury cabin, on the outside perimeter of the new spacecraft would provide the increased cabin space. This arrangement would also permit quicker replacement of defective units and allow for the jettisoning of exhausted containers or of systems no longer needed.

Gemini To Test Orbital Rendezvous.—Gemini will give an early capability to prove out the feasibility of rendezvous techniques. (See also Chapter 8, "Space and Aeronautics Research Activities.")

Costs Estimated.—Preliminary costs for the Gemini program were set at about $500 million, including 12 enlarged spacecraft and Titan II and Atlas-Agena vehicles. The Titan II, produced by Martin Marietta Corporation, would launch the Gemini capsule; and the Atlas, produced by Convair Division of General Dynamics Corporation, would propel the Agena stage with which Gemini would rendezvous.


PROJECT MERCURY
PROJECT GEMINI


PROJECT GEMINI
FLIGHT MISSION
1. ATLAS-AGENA B LAUNCHED
AGENA B
2. DETERMINE ORBIT OF AGENA B
TRACKING
& DATA ACQUISITION
CONTROL CENTER
& COMPUTING
3. SPACECRAFT LAUNCHED
SPACECRAFT
AGENA B
4. RENDEZVOUS DOCKING



Gemini two-man spacecraft.

Project Apollo

Project Apollo Accelerated

With manned lunar landing during the sixties established as a national objective, NASA accelerated all aspects of Project Apollo. (See NASA's Fifth Semiannual Report, Chapter 2, for a summary of the project.) NASA moved to award five major contracts for design and fabrication of the lunar spacecraft, its boosters, and its instrumentation; to expand launch facilities at Cape Canaveral; and to obtain bases in the Gulf-Mississippi River area for a Manned Spacecraft Center, a manufacturing plant, and a test facility. (For additional details on Project Apollo see Chapter 6, "Launch Vehicle Programs.")

Saturn Successfully Tested

Another achievement related to the Apollo program was the October 27 launching of the Saturn booster. In this ballistic test at Cape Canaveral, the Saturn performed as programmed, producing more than its planned 1.5-million pounds of thrust.

Preliminary Industry Conferences Held

To give industry the necessary background on Project Apollo, NASA held a series of briefings during the report period. The July meeting, held in Washington, D.C., was attended by 1,200 representatives from 300 companies to whom NASA officials explained the Apollo concept and requirements. Companies were requested to estimate their capabilities for contributing to the project, singly or as members of industry teams.

A mid-August briefing, held at Langley Field, Va., was limited to companies eligible to bid on the vehicle complex, including the three-man lunar capsule. This was a detailed technical briefing and indicated the contractual guidelines under which the proposals and preliminary bids were to be submitted. A third industry conference was held at New Orleans in September. Subsequently, NASA invited contractors to submit proposals on certain major systems and subsystems.

Apollo Spacecraft Builder Selected

Early in October, five industry proposals for the development of the Apollo spacecraft and the service module (carrying fuel, electrical power supplies, and propulsion units for lunar takeoff) were submitted to NASA. Each proposal was evaluated by a team of NASA and DOD engineers, scientists, and management personnel.

On November 28, NASA announced the selection of North American Aviation, Inc. (NAA) to design and build the three-man Apollo spacecraft and the second unit. NAA will be assisted by a large team of subcontractors. Details of the contract, expected to exceed $400 million, are to be worked out in negotiations between NASA and NAA officials.

Saturn Contracts Announced

In November, NASA announced that it had selected the Chrysler Corporation with which to negotiate a contract, ultimately to cost $200 million, to build, check out, test, and launch the first stage of the Saturn launch vehicle. Under the contract, Chrysler will fabricate a total of 20 first stages at the NASA Michoud Plant. The first Saturn stage manufactured by Chrysler, is scheduled for shipment to Cape Canaveral in 1964.

In December, NASA selected the Boeing Company with which to negotiate a contract to develop, construct, and test the first stage of the Advanced Saturn launch vehicle. The contract, to extend through 1966, covers work on 24 flight boosters as well as several ground test versions.

This stage is also to be assembled at the Michoud Plant and tested at the NASA Mississippi Test Facility; the NASA Marshall Space Flight Center will direct the work.

Also in December, a contractor was designated for the Saturn third stage. NASA indicated that it would negotiate with Douglas Aircraft Company, Santa Monica, on a contract to modify the Saturn S–IV stage for advanced missions. The modified stage, the S–IVB, will have its power increased by the installation of a 200,000-pound-thrust Rocketdyne J–2 liquid hydrogen-liquid oxygen engine.

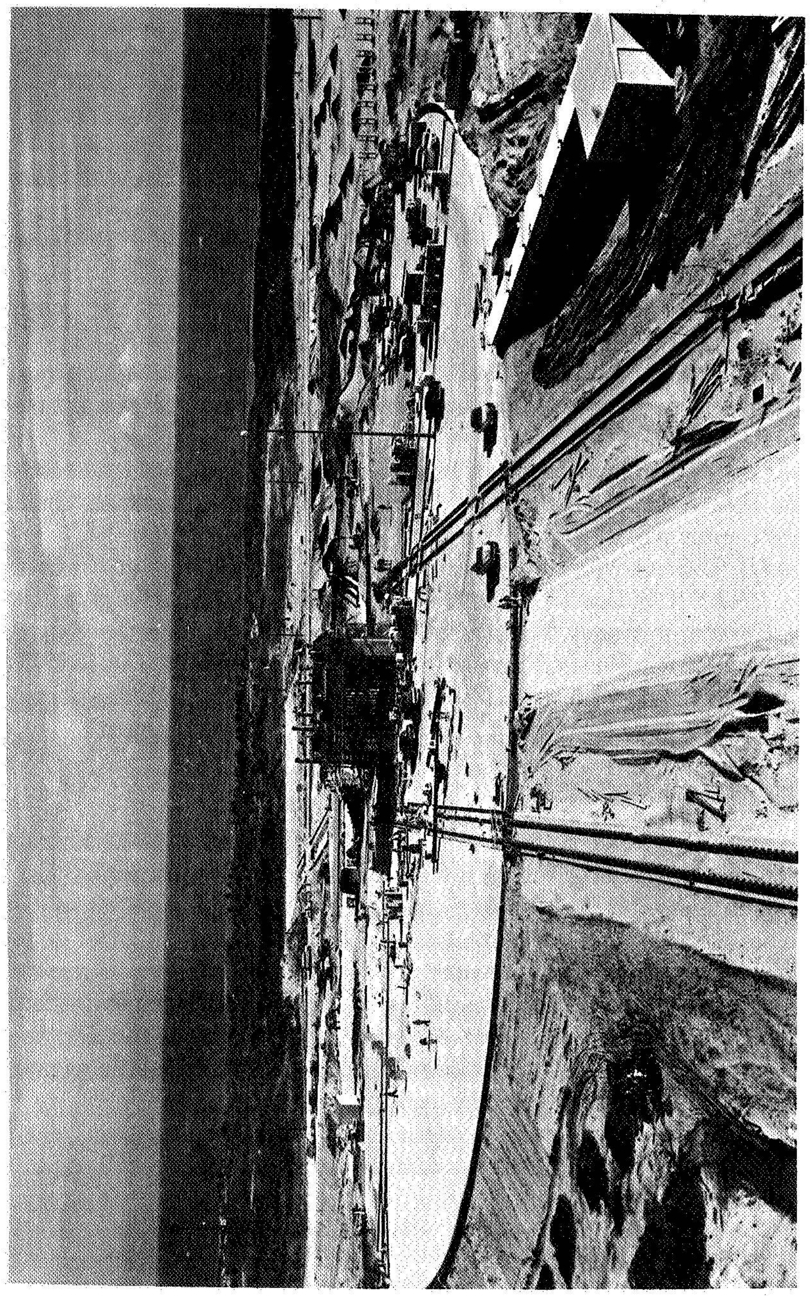
Guidance Contractor Selected

In August, NASA announced that it would negotiate a contract with the Massachusetts Institute of Technology Instrumentation Laboratory, Cambridge, to develop the guidance-navigation system for the Apollo spacecraft. The contract with the Laboratory, first member of the Apollo contractor team, will cover development of ground support and checkout equipment as well as the on-board system. Under the contract, the Laboratory will design and build the first few systems; later, contractors will be selected to manufacture the various elements of the systems under the technical direction of MIT.

The guidance-navigation system contractor was chosen early because development of this system is basic to the overall Apollo mission.

Expanded Facilities Required

Apollo Launch Site Set.—The size and power of the Apollo launch vehicles present problems of lethal noise levels and tremendous explosive forces. NASA had to consider these factors in selecting the Apollo launch site, as well as the need to develop such facilities in



Saturn launch site nears completion at Cape Canaveral.

time for preliminary Saturn tests in 1963. A decision was made to enlarge the Atlantic Missile Range (AMR) at Cape Canaveral by acquiring 80,000 acres north of the existing range.

NASA also contracted for the building of the second launch Saturn complex (No. 37) and an assembly building.

Gulf Area Bases Obtained.—NASA also took over the 2-million square-foot Michoud Ordnance Plant, Michoud, La., as a manufacturing and assembly site for Saturn stages. In addition, NASA acquired the Mississippi Test Facility, 50 miles east of New Orleans, as a static test site for Saturn and Nova-class vehicles.

Manned Spacecraft Center Added.—In September, NASA announced that the administrative, testing, and training headquarters for the manned space flight program will be located in Houston, Tex. The facilities will be built on a 1,620-acre plot—1,020 acres deeded to the Government by Rice University, 600 acres purchased by NASA.

CHAPTER 2

Satellite Applications

Advances Continue

NASA progressed in its development of an operational meteorological satellite and continued research on technical problems yet to be solved before operational communications satellites can be established.

TIROS experimental weather satellites continued to make meteorological history. TIROS III was launched—the third launch, without a failure, of this family of satellites—and soon began tracking and discovering Atlantic hurricanes and Pacific typhoons. TIROS II, a year in orbit on November 23, provided valuable pictures until August and limited data almost to the end of the report period. Although no longer transmitting data, TIROS I continued to be the subject of numerous technical reports, and demands for its pictures increased.

The TIROS satellites proved so useful that it was decided to attempt to keep one in operation at all times until the first of the successor series—Nimbus—is launched. Work on TIROS IV was undertaken, and the satellite was nearing readiness for launching at the end of the report period. (It was launched February 8, 1962, from Cape Canaveral.)

Development of Nimbus continued, and initial in-house studies were undertaken on Aeros, planned as the first weather satellite to be placed in a 24-hour "stationary" orbit—one synchronous with the rotation of the earth.

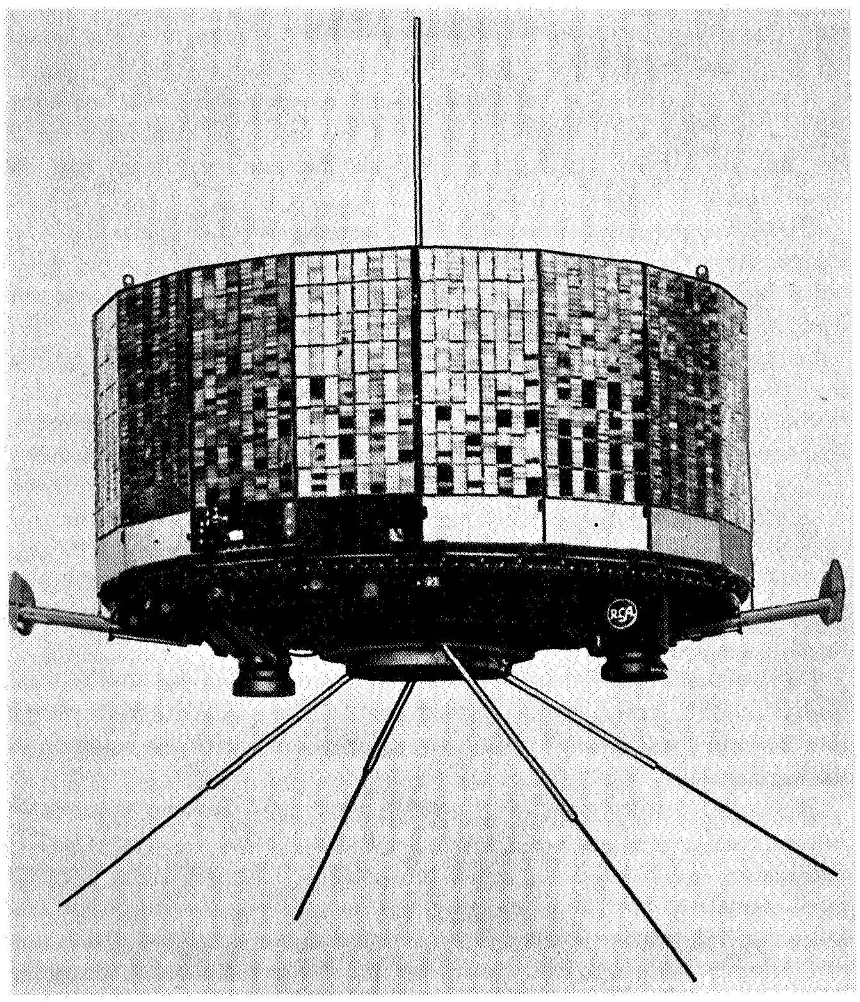
Research, development, and testing continued on two systems of communications satellites—passive (reflecting transmissions received) and active (retransmitting received signals). Preparations were almost completed for suborbital testing of a passive satellite larger and more rigid than the 100-foot Echo I (in orbit since August 1960), and preliminary investigations continued on Project Rebound, designed to place three advanced Echo satellites in orbits from a single launch. Developmental work progressed on the Relay, Telstar, and Syncom active satellites.

Meteorological Satellites

Tiros III

Launched from Cape Canaveral, July 12, 1961, by a Delta launch vehicle, TIROS III achieved a near-circular orbit at an altitude of about 475 miles.[1]

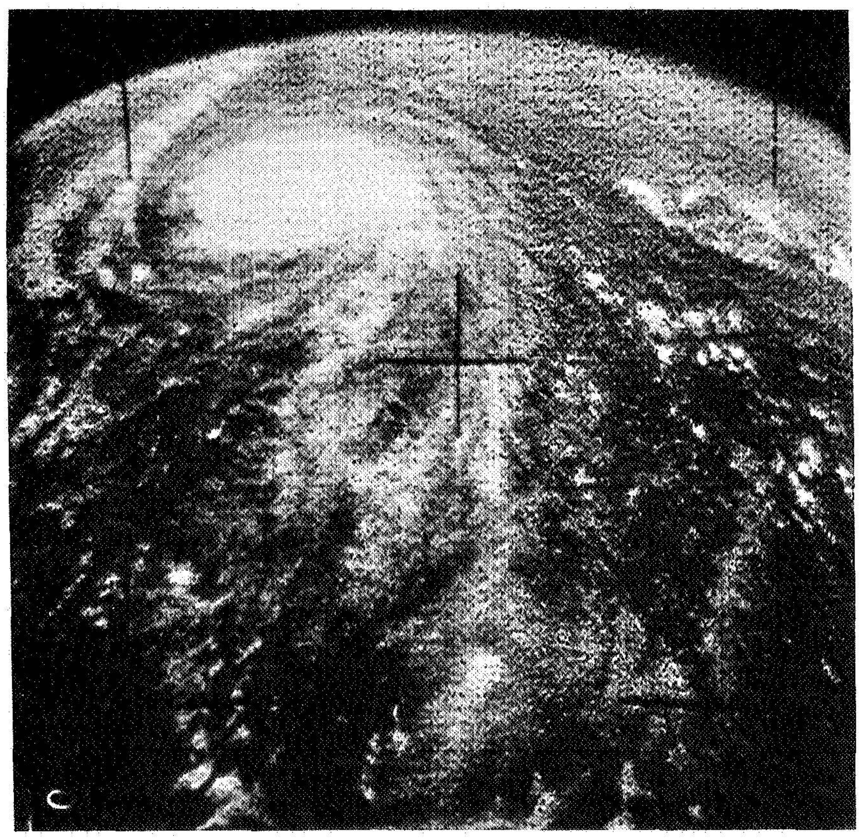
Discovers Tropical Storms.—The first weather satellite to discover and provide the first data on a fully developed hurricane—Hurricane



TIROS III meteorological satellite.

[1] See NASA's Fifth Semiannual Report to Congress, Chapter 9, *Satellite Development*, for improvements in TIROS III over earlier weather satellites.

Esther, on September 11—TIROS II transmitted timely storm-revealing pictures of cloud systems (as well as infrared data) from vast areas of the earth. For example, TIROS III pictures televised on the same day the satellite discovered Hurricane Esther provided data on several other widespread storms extending from Hurricane Debbie in the mid-Atlantic to Typhoon Paula near Formosa.



TIROS III photograph of Hurricane Betsy September 7, 1961.

In the ocean areas west of Baja, Calif., the satellite discovered several tropical storms and established the locations of others. It thus demonstrated that meteorological satellites can provide data of importance to areas, such as these, that normally are almost completely without sources of continued weather information and that carry on important economic activities, such as fishing.

Provides Valuable Weather Data.—TIROS III proved its ability to help overcome the deficiencies of other methods of weather observation. Cloud pictures it transmitted on September 24 and 25 showed that Typhoon Sally had not degenerated, as weathermen relying on conventional data had believed.

From cloud cover data furnished by TIROS III, the Weather Bureau's Meteorological Satellite Laboratory and National Meteorological Center were able to provide United States and foreign weather stations with valuable weather and cloud maps and analyses and to flash special alert messages to areas threatened by dangerous storms. At New York, cloud analyses and pictures were used to brief pilots flying the Atlantic and incorporated in weather kits carried by them.

TIROS III has transmitted over 35,000 pictures. These and the infrared data it has recorded on the working of the earth's weather-making heat balance are being used to increase meteorological knowledge through research.

Attitude Changes Studied.—In late October, attitude changes in TIROS III could not be explained by the design or operation of the controllable magnetic coil that influences its attitude and the direction in which its cameras point. NASA scientists are studying these changes in an effort to relate them to what is known of the earth's magnetic field.

Now an Engineering Experiment.—TIROS III's infrared detectors obtained no usable data after October 30, and its television cameras none after December 5. This satellite is therefore now little more than an engineering experiment. (TIROS III was turned off shortly after TIROS IV was successfully launched and was working.)

International Aspects.—NASA and the Weather Bureau invited all nations belonging to the World Meteorological Organization to make special ground observations when TIROS III was over their territories. Twenty-nine nations took part in the program.

NASA and the Weather Bureau sponsored the International Meteorological Satellite Workshop, held in Washington, D.C., November 13 through November 22, 1961. Thirty-nine participants from 27 nations took part; 1 additional nation sent an observer only. The participants attended lectures on research progress on meteorological satellites and laboratory sessions on processing and interpreting TIROS data.

Tiros II

TIROS II was still transmitting an occasional usable picture in December, a year after launch. Although its radiation sensors can no longer provide data of meteorological value, the tape recorders and electronic systems for recording meteorological information continue to function and to provide valuable engineering data.

Fourth Pair of Spin-Up Rockets Fired.—A fourth pair of the rockets controlling spin rate were activated on ground command after the satellite had been more than 10 months in space. Firing of these rockets increased the spin rate by two revolutions per minute, two-thirds of design impulse.

TIROS II Data Studies Continued.—The Weather Bureau and the Navy Hydrographic Office continued to study pictures of the Gulf of St. Lawrence televised by TIROS II cameras during January and March 1961.

During the report period, Goddard Space Flight Center, assisted by the Weather Bureau's Meteorological Satellite Laboratory, processed radiation data transmitted by TIROS II and recorded this data on magnetic tapes for research use with computers. Radiation charts were produced from these tapes. The tapes and charts for 50 orbits were made available to United States and foreign scientists, whose comments will be considered in establishing the best method for reducing and presenting similar TIROS III data.

Tiros I

Although the first satellite of the TIROS series has yielded no useful data for more than a year, it continued to be written about and discussed. The first of its cloud pictures were placed on public sale in July, and a complete catalog of these pictures was issued in the fall.

Tiros IV

Plans call for the launching of four additional TIROS satellites, one about every 4 months, with the last launch overlapping the first Nimbus launch.

TIROS IV, the next of the TIROS series, was nearing completion at the end of the report period. One of its cameras has a new medium-angle lens. Although this lens somewhat reduces the area photographed, it gives more detail and produces less distortion than the wide-angle lens of previous TIROS cameras. As a result, meteorologists will be able to locate and evaluate TIROS IV cloud pictures more precisely.

Some of the wavelengths observed with the scanning radiometer have also been changed to determine whether the deterioration in previous TIROS detectors resulted from (1) the action of the space environment or the sun's ultraviolet radiation on the filters or (2) the physical location of the detectors in the satellite.

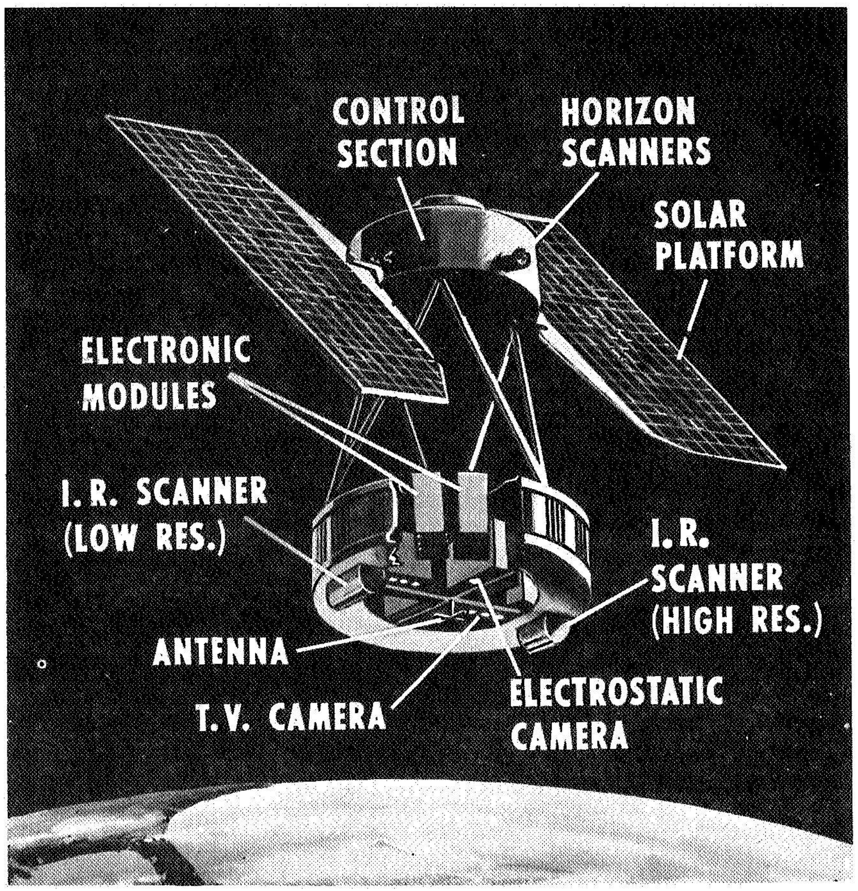
Vibration tests were satisfactorily completed early in December and were followed by thermal-vacuum tests.

656299 O—62——4

Nimbus

Work progressed on the Nimbus experimental weather satellite, scheduled to be launched in 1963. Nimbus will carry improved equipment that will make it more useful and more nearly operational than TIROS III. In addition, it will be launched into a quasi-polar orbit and its TV cameras will be focused on the earth at all times. As a result, it will be able to provide full coverage of the daytime cloud cover of the entire earth every 24 hours.[2]

Equipment Passed Tests.—The prototype medium-resolution radiometer transmitter successfully passed environmental tests, and the vibration model of the spacecraft's sensory ring passed certain flight



Nimbus meteorological satellite.

[2] See NASA's Fifth Semiannual Report to Congress, Chapter 9, *Satellite Development*, for additional information on this satellite.

level tests. Acceptance testing of the preprototype control and stabilization systems was started but could not be completed because of deficiencies in the testing facilities. Further testing was suspended until improved testing facilities are completed at the General Electric plant at Valley Forge, Pa.

Aeros

NASA undertook initial in-house studies and research and development on components eventually to be incorporated into the Aeros meteorological satellite.

Constant Weather Surveillance.—Aeros will be placed in an equatorial orbit at an altitude of 22,300 miles. Its unusual feature will be its more or less "stationary" position in relation to the earth. It will maintain constant surveillance of weather systems in the tropical and temperate latitudes and will therefore be able to continuously track a storm developing or moving within these latitudes.

Aeros is expected to have a camera for viewing major cloud systems and another for viewing any selected area in greater detail.

National Meteorological Satellite System

NASA will participate extensively in the National Operational Meteorological Satellite System (NOMSS), to be managed by the Weather Bureau under legislation enacted by Congress September 30, 1961. NOMSS will eventually enable meteorologists to use satellite observations as routinely as they now use ground and balloon observations.

NOMSS will be based on the Nimbus program. NASA and the Weather Bureau have informally prepared a Preliminary Project Development Plan for the Nimbus Operational System (NOS), the first phase of NOMSS. Under the plan, NASA will be responsible for developing and launching spacecraft, developing ground command and data acquisition stations, and acquiring data from the satellite. NASA and the Weather Bureau will process these data, which will be analyzed by the Weather Bureau for use in operational weather analyses and forecasting. The data will also be retained for research and development and climatological use.

Communications Satellites

Echo

While studies of the environmental behavior of Echo I continued, work went forward on the larger and more rigid Echo II.[3]

[3] Described in NASA's Fifth Semiannual Report to Congress, Chapter 9, "Satellite Development".

Langley Research Center conducted a successful vacuum tank inflation test of the Echo II rigidized aluminum-plastic laminate sphere. This test was a preliminary to suborbital tests of the ejection and inflation of the sphere scheduled for January 1962.

Rebound

NASA is studying a technique by which a spacecraft launched by a single launch vehicle will eject three or more Echo satellites (later, active satellites as well) individually at predetermined intervals so that they will be equally spaced in a circular earth orbit. The purpose of this project—Rebound—is to reduce the cost of establishing multiple low-altitude communications satellite systems. These studies are expected to lead to two launches in 1963, using Atlas-Agena B launch vehicles.

Rebound Design Contract Awarded.—The Douglas Aircraft Corporation completed, under NASA contract, the initial design study of the multilaunch Rebound spacecraft. NASA reviewed the study and concluded that further work on the spacecraft design is necessary. It is planned to extend the contract for three months.

Relay

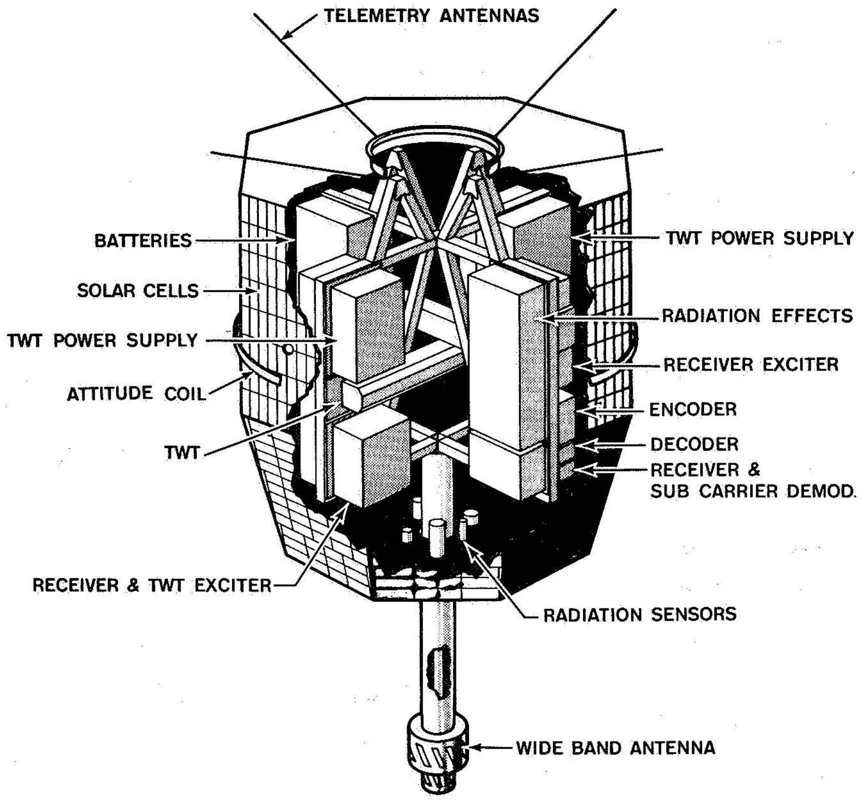
The objective of Project Relay is to test the ability of an active satellite to transmit transoceanic multichannel telephone, telegraph, and television messages.

The 125-pound Relay experimental communications satellite, which will have 1 one-way TV channel or 12 two-way voice channels, is to be launched by a Thor-Delta rocket system into an elliptical orbit with a perigee of about 900 and an apogee of about 3,000 miles.

Design and Fabrication Program Advancing.—Radio Corporation of America, the prime contractor for the Relay spacecraft, completed most of the electronic design and constructed the shock and vibration and the thermal models.

Ground Stations Being Constructed.—NASA initiated preparations for constructing a ground test station at Goldstone, Calif., for Project Relay. Under a $1,200,000 contract, the Philco Corporation is furnishing a 40-foot antenna for this station.

The United Kingdom and France also carried on construction work on ground stations to be used in Project Relay as terminals in trans-Atlantic communications experiments. Representatives of NASA and of these and other countries interested in the project reviewed ground station planning at a conference held in Washington, D.C., December 8 and 9.



Project Relay satellite.

Telstar

A Cooperative Project.—NASA and the American Telephone and Telegraph Company are cooperating on the Telstar project. The objective is to investigate the transmission of wideband communications by an active communications satellite. To meet this objective, NASA plans to launch two Telstar spacecraft from Cape Canaveral during 1962. A backup launch 2 months later is planned for each scheduled launch should a failure occur. Telstar's orbit will be elliptical, with an apogee of about 3,000 miles, a perigee of about 500 miles, and an inclination of 45° to the equator.

NASA and the American Telephone and Telegraph Company (which is assuming all costs) have the following responsibilities for the project:

NASA—Establishing environmental test specifications for the spacecraft, obtaining the launch vehicle, launching the spacecraft, and acquiring orbital data.

A.T. & T.—Developing the spacecraft and ground stations.

NASA and A.T. & T.—Analyzing and processing data for research and development on the spacecraft and ground systems.

To Receive and Send Signals.—The Telstar spacecraft will be nearly spherical, 34 inches in diameter, and weigh about 170 pounds. Its communications equipment is designed to receive radio signals and immediately amplify and retransmit them on another frequency. This equipment will also be able to accommodate one standard TV channel or 60 two-way telephone channels. Electrical energy will be furnished by 3,600 solar cells, which convert sunlight into electrical energy.

The spacecraft also is planned to carry equipment to record the effects of radiation and environment on its critical components.

Ground Station Being Constructed.—The American Telephone and Telegraph Company is constructing at Andover, Maine, a ground station to support Telstar. The station, which is to have a 60-foot horn-type antenna, is also to be used for Project Relay.

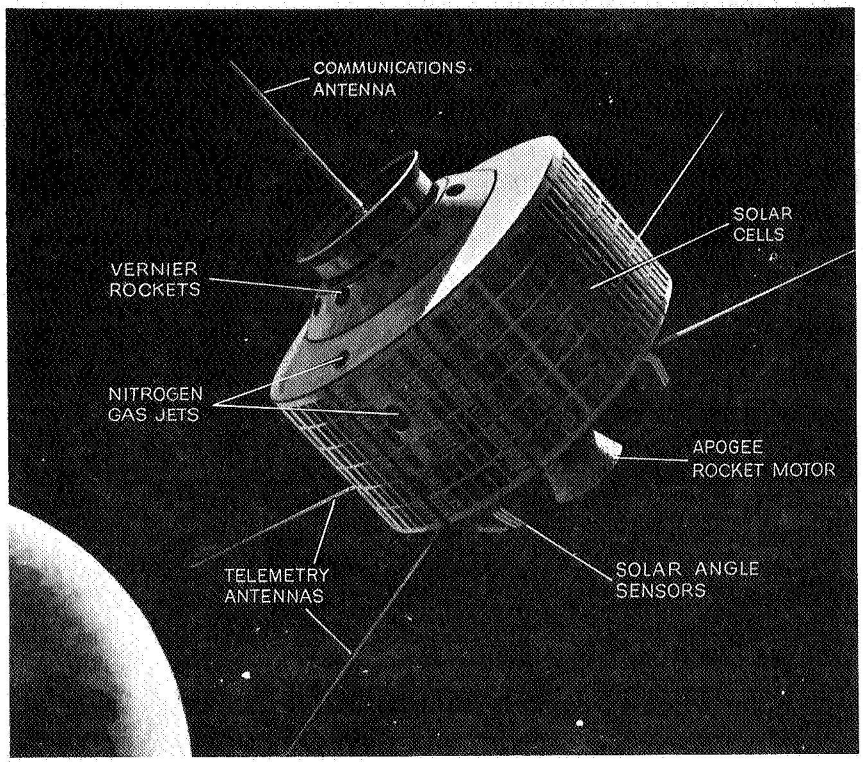
International Aspects.—Plans call for Telstar also to use ground stations being constructed for Projects Relay and Rebound by the British General Post Office, the French Center for Telecommunications Studies, the West German Post Office, and the Brazilian Department of Posts and Telegraphic Communications. Other countries, notably Canada, Japan, Italy, and Argentina, are actively interested.

Syncom

Syncom, under a NASA contract, is to be built by the Hughes Aircraft Company. It will be the first NASA communications satellite in a 24-hour orbit, that is, making an orbit once each 24 hours, its speed exactly coinciding with the earth's rotation. Inclined 33° to the equator, Syncom will appear to an observer on the earth's equator to move back and forth daily from a point directly over 33° north latitude to one over 33° south latitude.

The Syncom spacecraft is cylindrical, 25 inches high, and 28 inches in diameter. It will weigh about 125 pounds, of which 70 pounds will be the weight of the fourth-stage "apogee kick" rocket motor—which adds the thrust required to place the spacecraft at the apogee (24-hour) altitude. Syncom's communications equipment will receive radiotelephone and radiotelegraph messages from the earth and immediately retransmit them.

Two Launchings Planned.—Project Syncom has two objectives: (1) to develop the capability to launch satellites into 24-hour orbits, using existing launch vehicles and apogee kick rocket motors; and (2) to test the life of the communication equipment, power supply, and



Syncom communications satellite.

attitude control system at the 24-hour orbit altitude (22,300) miles. To meet these objectives, NASA plans two Syncom spacecraft launchings—one late in 1962, the other late in 1963. A backup launch is planned, if either of the scheduled launchings fails.

Orbited by Fourth-Stage Rocket Motors.—Delta vehicles have been selected to launch the Syncom spacecraft from Cape Canaveral. About 5½ hours after launch, the satellite will be over the southeast coast of Africa at the apogee of a long, narrow elliptical orbit (perigee will be at 125 miles). The fourth-stage rocket motor will then be fired to impart enough additional velocity to place the spacecraft in a nearly circular, approximately 24-hour orbit; the rocket motor will not, however, impart enough velocity for the spacecraft to appear stationary.

Vernier Rockets for Positioning.—The earth will turn under Syncom, which will appear to drift back westward. When the satellite arrives over the desired longitude, enough of its 10 vernier rockets will be fired to provide the additional velocity necessary to make it appear to stop near the selected meridian. At this time the satellite's two nitrogen jets will be operated by ground command to make the final adjustment necessary to bring the satellite to the selected position and to orient it properly so that its antenna beam is pointed toward the earth.

DOD Participating in Project Syncom.—NASA and the Department of Defense have the following responsibilities for Project Syncom:

NASA—Developing and launching the spacecraft and acquiring and processing orbital data.

DOD—Developing the ground station.

NASA and DOD—Analyzing and processing data to support research and development on the spacecraft and ground systems.

The fixed ground stations under construction for Project Advent—a Department of Defense program to develop a military communications satellite—may also be used for Syncom.

Geophysics and Astronomy Programs

Experiments Expand Knowledge

During this period significant advances were made in knowledge of the earth's space environment and the complex relationship between the earth and the sun. To achieve these advances, NASA launched two geophysical satellites, a geophysical probe, and 28 sounding rockets. (For details of the satellites and probe, see table 1, p. 58.)

The major contributor to this knowledge was Explorer XII. This satellite transmitted valuable data that (1) altered the accepted image of the Van Allen Radiation Region, (2) revealed that the earth's magnetic field has a definite outer edge, and (3) furnished new evidence of how solar events affect the earth.

The individual discoveries described in this chapter should be considered in the light of a broad program designed for greater understanding of the earth and the universe. Eventually, enough of the relatively isolated pieces of information will be acquired to form collectively a greatly improved picture of an area of science. Such increased understanding could lead in time to vast practical benefits for mankind.

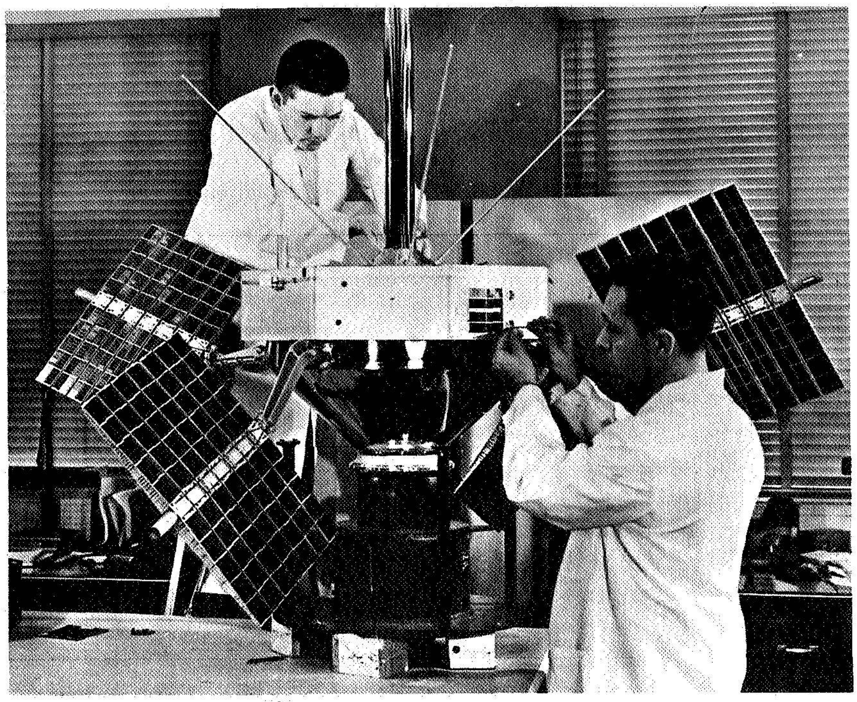
Explorer XII Energetic Particles Satellite

Nature of Charged Particles

Explorer XII, launched August 15 by a Delta vehicle, carried instruments for making an intensive and extensive study of energetic particles in space. Such particles are free ranging protons and electrons stripped from atoms (usually hydrogen) and coursing through space at speeds approaching that of light. These particles constitute much of the dangerous radiation in space.

Unusual Range of Instrumentation

Explorer XII carried instruments to monitor particles trapped in the magnetosphere (a region of space extending from the earth's surface to the upper edge of earth's magnetic field); particles streaming from the sun, including those which are hurled outward during a solar flare and are termed the "solar wind"; and cosmic rays (ex-



Technicians work on Explorer XII before launch.

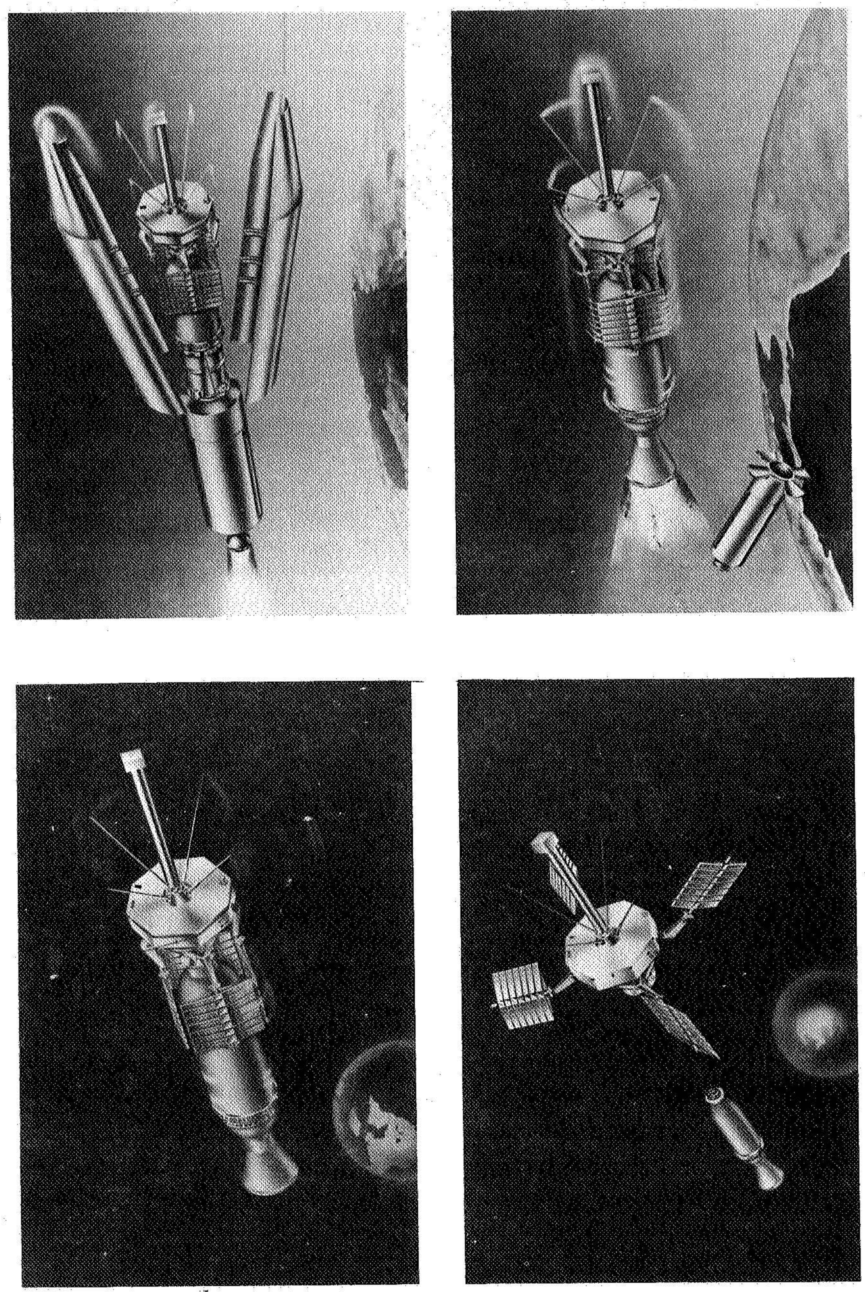
tremely high-energy particles) for correlating data on particles with data on magnetic fields which deflect, guide, or trap particles speeding toward earth from space. (Simultaneous measurements of particles and magnetic fields help establish influence of the fields on movement of particles.) Packing of 10 different particle-detecting systems into the small (27-inch diameter, 19-inch high) satellite represents a milestone in engineering.

Orbit Adds to Value

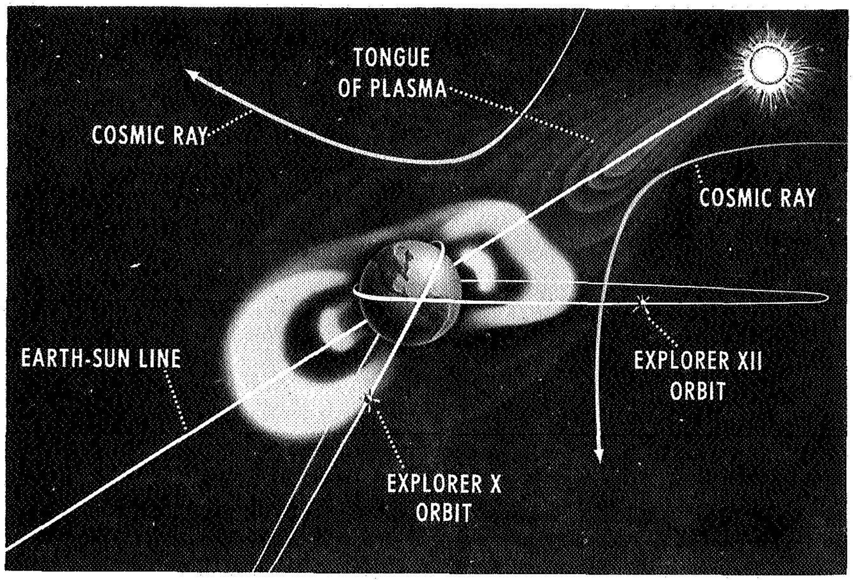
The orbit of Explorer XII, initially 180 miles at perigee and 47,800 miles at apogee, was very close to that planned. This extremely eccentric orbit made possible acquisition of data from regions near the earth to interplanetary space beyond the earth's magnetic field.

Provides Abundant Data

More useful data were obtained from Explorer XII than from all prior satellites combined. During its 112-day operating lifetime, Explorer XII radioed more than 3 billion bits of useful information to earth. About 80 percent was stored on 5,600 spools of magnetic tape which if unwound and laid end to end would stretch approximately



Orbiting of Explorer XII (and Explorer X).



Radiation belt studies.

2,500 miles. It has been calculated that 5,600 spools would record an estimated 100 million five-letter words and that a stenographer typing 60 words per minute would have to work continuously for more than 3 years to do a comparable job.

Life Cut Short

An unexplained failure abruptly halted Explorer XII broadcasts on December 6. NASA had programed the satellite for a year of operation. NASA is testing and evaluating a satellite essentially identical with Explorer XII for later launch into a similar orbit.

Preliminary Findings

New Image of Van Allen Radiation Region.—Data from Explorer XII reversed previous conceptions of the Van Allen Radiation Region. They disclosed that relatively slow-moving protons as well as electrons are its chief constituents and that the entire Region is actually a single system of charged particles instead of two distinct belts. These particles are trapped in the earth's magnetic field.

Particle Distribution Mapped.—The mixture of charged particles varies from altitude to altitude. For example, at 2,000 miles, the predominant particles are protons with energies of tens of millions of electron volts (MEV); at 8,000 miles, protons with only a fraction of an MEV predominate; and at 12,000 miles, protons with energies between 0.1 and 4 MEV and electrons with energies up to 2 MEV predominate. (An electron volt is a scientific yardstick for distinguishing the relative energy levels of charged particles. It represents the energy the particle would acquire by moving through an electric field difference of one volt.)

Outer Area Contains Many Low-Energy Protons.—Data from Explorer XII showed that the outer area of the Van Allen region contains a large number of low-energy protons—which pose little radiation hazard to manned space flight—and that the intensity of the electrons in this area is 1,000 times less than interpretations of previous measurements had indicated. (The Explorer XII data did not materially change previous findings that the inner area of the region is dominated by high-energy protons.)

Implications of New Radiation Region.—Slower-moving protons pose less of a radiation hazard than high-energy electrons. Men passing quickly through the outer area of the radiation region—with its low energy protons and high energy electrons—on the way to the moon or beyond would be in little danger from the protons but would need to be protected from X-rays generated by the electrons. However, even in heavily shielded vehicles, prolonged flight in or repeated passages through the inner area of the region of energetic protons would be deadly.

Geomagnetic Field Has Distinct Boundary.—The earth's magnetic field, instead of gradually merging into interplanetary space, has a distinct, sharp outer boundary where both particles and magnetic field stop. Beyond the boundary is a turbulent region about 12,000 miles across, marked by fluctuating magnetic fields and solar winds; beyond this, interplanetary space begins.

Solar Wind Affects Magnetic Field.—Explorer XII showed that the magnetic field's outer boundary ranges from 30,000 to 40,000 miles from earth. Data from Explorer X, NASA's magnetometer satellite, had indicated that the boundary of the earth's magnetic field was at a distance of 80,000 miles. Explorer XII measurements were taken at a point between the sun and the earth, and Explorer X measurements were taken over an area of earth at an obtuse angle from the sun. The figures suggest that the solar winds—clouds of charged particles thrown from the sun—compress the earth's magnetic field on the sun's side and blow it out on the other side.

Solar Event Effect on Earth.—Explorer XII monitored effects of four solar flares. On one occasion, September 28, Explorer XII instruments detected energetic charged protons within a few hours after a solar flare. Intensity of the protons died down after five hours. Two days later, Explorer XII reported a sudden increase in low-energy protons in the vicinity of the earth. Simultaneously, a magnetic storm erupted on earth, and bright auroral displays occurred at low altitudes in many places, including Washington, D.C. It is theorized that the flare hurled low-energy protons which, dragging the solar magnetic field, traveled from sun to earth at about 1,000 miles per second. During such an event, lethal radiation would endanger space travelers between the earth and the moon.

Solar Pressure Again Demonstrated.—Sunlight pressure was first satisfactorily demonstrated when its effects were observed on the orbits of Vanguard I and Echo I. It was again evidenced on the 83-pound Explorer XII. Beating upon the satellite's four broad solar cell paddles, the pressure of sunlight increased the satellite's spin rate from an initial 27 to 33 revolutions per minute on December 6, when satellite transmissions ended.

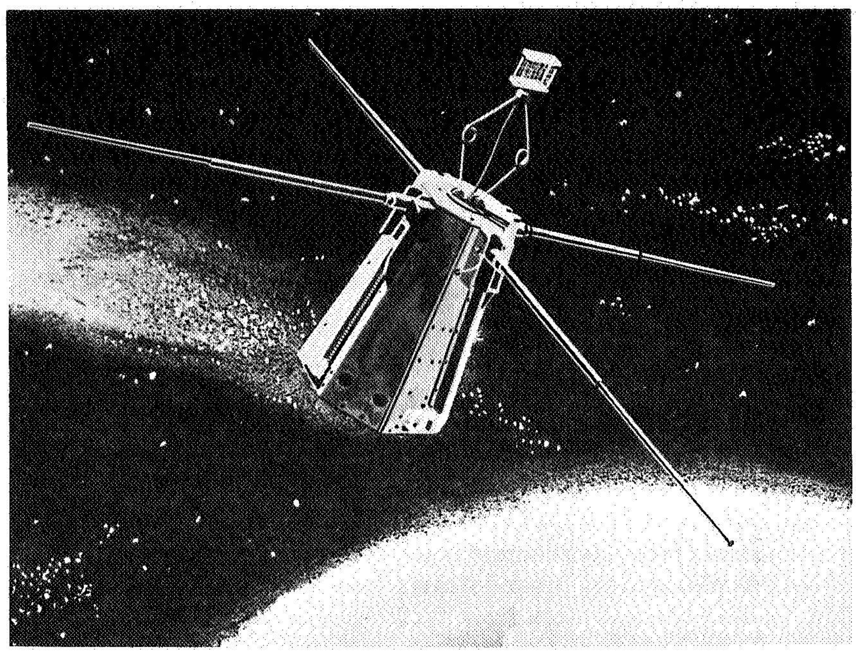
Solar Cell Experiment.—NASA installed four banks of solar cells on the satellite's outer surface to measure deterioration caused by radiation and to compare the effectiveness of varying thicknesses of glass coatings. One bank was unshielded. The other banks had glass protective coatings of 3, 20, and 60 mils (thousands of an inch), respectively. Power from the bare solar cells was halved by August 18; by September 14 it was reduced by 85 percent. In the same period, cells with 3 mils of coating lost 5 percent of their output; those with 20 to 60 mils continued fully efficient. These data are contributing to the design of solar-powered satellites, such as the Relay medium-altitude active communications satellite, which must traverse the Van Allen Radiation Region. (Solar cells convert sunlight to electrical power for operating spacecraft instruments.)

Explorer XIII Micrometeoroid Satellite

On August 25, a Scout launch vehicle orbited Explorer XIII to gather data about micrometeoroids (cosmic dust) at altitudes from 200 to 600 miles. The orbit attained was not, however, as programed; its perigee, about 75 miles, dipped into the denser portion of the earth's atmosphere where air drag decelerated the satellite from the speed needed to remain in orbit. On August 27, after 2½ days aloft, Explorer XIII plunged toward earth.

Electron Density Profile Probe (P–21)

On October 19, a Scout vehicle launched from Wallops Station, Va., carried an ionosphere probe to a maximum altitude of 4,261 miles



Electron Density Profile Probe—P–21 (artist's conception).

before descending to earth. The probe was designed to provide information about the relatively unexplored region of the ionosphere at altitudes above 200 miles. Increased knowledge of this electrified region of the atmosphere may lead to improved world radio communication and greater accuracy in ground tracking of spacecraft.

Confirms Presence of Helium Layer

The P–21 probe supported earlier indications of a helium layer in the atmosphere between the altitudes of about 700 and 1,500 miles. This layer, sandwiched between a lower region where oxygen predominates and an upper region constituted chiefly of hydrogen, was first indicated by the Explorer VIII satellite launched November 3, 1960.

Provides New Data on Electron Density

The probe transmitted measurements of electron density at various altitudes from 300 to 1,800 miles. It indicated that electron density in the upper ionosphere was lower than that which had been assumed, based upon knowledge of the ionosphere's underside. Temperature was found to be fairly constant at 2,000° F. between the altitudes of 300 and 1,800 miles. Acquisition of useful data was curtailed at about 1,800 miles altitude by unexpected radio interference from a man-made source. The low-frequency waves needed for ionospheric research are also used for commercial communication.

Similar Midnight Launch Planned

P–21 was launched at 1:38 p.m., e.d.t., during the warmest portion of the day. Scientists theorize that electron density, altitude of the helium layer, and temperature of the upper atmosphere drop sharply when the sun is not overhead. NASA plans a midnight launch of another P–21 probe to provide evidence for supporting or refuting these theories.

Rocket Exhaust Disturbs Ionosphere

Ground monitors noted that during part of the flight the Scout's exhaust so disturbed the ionosphere that it interfered with some of the probe's radio transmissions. The fact that gases from a rocket could disturb radio broadcasts in the ionosphere is considered important from both scientific and engineering viewpoints.

NASA relocated the ground station from Wallops to Blossom Point, Md., so that transmissions from future probes may bypass the region of the ionosphere disturbed by the launch vehicle's exhaust.

New Findings From Previously Launched Satellites

Explorer IX Reports Thinning of Upper Air

Observations of Explorer IX, the 12-foot diameter balloon satellite launched February 16, 1961, disclosed a tenfold decrease since 1959 in atmosphere density at 420 miles altitude. The decrease is believed due to the declining trend of sunspot since the high point reached in 1959.

Sunspots fluctuate in regular cycles, with about 11 years between periods of peak activity. During these peaks, increased heating takes place in and expands the upper atmosphere, thereby increasing the quantity of air molecules at high altitudes.

Intermediate Changes in Air Density.—Study of Explorer IX orbital changes also revealed that air density varied from day to day and with the 27-day rotational period of the sun. Sudden increases in air density were noted during violent magnetic storms triggered by solar flares.

Density Measurements at 420-Mile Altitude.—Based on Explorer IX data, air density 420 miles above earth is 100 quadrillionth gram per cubic foot. If this region of space could be scaled up so that air molecules were the size of tennis balls, the tennis balls would be more than 20 miles apart. Thickness of air at this altitude is 40 trillion times less than at the earth's surface.

Data Calculated by Watching Satellite.—Explorer IX is an inflated balloon structure with an outer skin made up of two-thousandths-inch-thick plastic and aluminum foil. Its large size (12-foot diameter) and light weight (14½ pounds) enable almost undetectable wisps of air to retard the satellite and alter its orbit. Air density data are based upon these observed changes. Explorer IX is expected to furnish valuable data about altitudes as low as 100 miles as it spirals down toward earth.

Explorer XI Data Contradicts One Theory of the Universe

Data from Explorer XI, the gamma ray astronomy satellite launched April 27, 1961, challenge the theory that the universe is in a steady state. According to this theory, matter and antimatter are continuously and simultaneously being created throughout the universe. (Particles of antimatter are the same as particles of matter except that they have an opposite charge; for example, protons in matter are positively charged particles but protons in antimatter are negatively charged.) When matter and antimatter collide, they annihilate each other, leaving behind only energy in the form of extremely powerful gamma rays. However, the intensity of gamma radiation detected by Explorer XI was about one thousand times less than that which would result from the annihilation of matter and antimatter in space.

Indirectly, Explorer XI findings lend support to the opposing theory on the origin and evolution of the universe. This hypothesis is that the universe began with the explosion aeons ago of an extremely dense and massive lump of matter and that fragments of this matter are still hurtling outward, making for a constantly expanding universe.

Satellites Under Development

Geophysics Program

While NASA has made substantial scientific progress, these very advances have revealed the complexity of our environment and the need for increased observation and study. Geophysical satellites under development to accomplish this goal are described in NASA's Fourth and Fifth Semiannual Reports to Congress. They include:

Atmospheric Structure Satellite (S–6).—S–6 will gather data on the composition, pressure, density, and temperature of the upper atmosphere and on variations caused by solar phenomena.

656299 O—62——5

International Satellites, UK No. 1 and 2 (S–51 and S–52).—Prepared by Great Britain for launch by NASA's Delta vehicle, these satellites will probe the ionosphere, the region of space vital to worldwide radio communication.

Topside Sounders.—One satellite is being prepared by Canada for launch by NASA. Another is under development by NASA. Both will examine the ionosphere by bouncing radio signals from its upper surface, thereby obtaining data not previously available. The U.S. satellite will sound the ionosphere at six radio frequencies between 2 and 15 megacycles, making rapid measurements. The Canadian satellite will continuously sweep the measuring frequency over the 2 to 15 megacycle range, obtaining more precise data than the U.S. satellite but at a much slower rate.

Orbiting Geophysical Observatory.—The Orbiting Geophysical Observatory will be able to carry as many as 50 different experiments and add substantial quantities of knowledge about the earth and its space environment. It is designed to be a standardized spacecraft with a high degree of flexibility for accommodating independent experiments with a minimum of lead time. On December 19, NASA selected experiments for the first OGO. These will cover a broad range of phenomena including magnetic fields; energetic particles; gamma, X-, Lyman Alpha, and cosmic radiation; micrometeoroids; and radio astronomy. This satellite (to be called EGO for *E*ccentric *G*eophysical *O*bservatory) will be launched into an acutely elliptical west-east orbit.

Astronomy Program

The atmosphere, without which there would be no life, also acts as a barrier to man's search for knowledge by veiling his sight of the heavens. NASA plans to circumvent this barrier with orbiting observatories that will view the universe from above the shimmering haze of the atmosphere. These satellites will observe clearly the full range of electromagnetic (light) radiation from the sun and other parts of the universe—including visible light such as blue and yellow, and light, such as ultraviolet, infrared, and radio waves, undetectable by man's senses. Through such observatories, man will be able to conduct an intense and sustained survey of the day-to-day behavior of the sun and to study distant galaxies. He will gain new understanding about the origin and nature of the solar system and of the universe; perhaps, even learn about the existence of other solar systems.

Orbiting Solar Observatory.—As the period ended, NASA was making final preparations for launch of the first Orbiting Solar Observatory (OSO), designed for intensive studies of the sun and its phenomena. The satellite is expected to furnish valuable data about gamma rays, ultraviolet radiation, X-rays, and other electromagnetic radiation which cannot be acquired by ground-based observatories. Leading astronomers have provided experiments for OSO. These experiments should add to understanding about our solar system and about solar effects on earth's weather and radio communication. An important goal is to develop a reliable system for long-range forecasts of solar flares. A reliable forecasting system would enable NASA to schedule moon journeys during relatively quiet solar periods.

Orbiting Astronomical Observatory.—A wealth of new knowledge about the solar systems, stars, and composition of space is expected from NASA's planned Orbiting Astronomical Observatory (OAO). This complex satellite will carry about a thousand pounds of scientific equipment such as telescopes, spectrometers, and photometers. It will incorporate highly advanced techniques for studying the ultraviolet light, thereby obtaining invaluable data on the makeup and evolutionary processes of stars. OAO will also be able to study the interplanetary medium (clouds of hydrogen gas in space between celestial bodies) under conditions that should reveal much about the fundamental nature of the universe.

Sounding Rockets

Play Many Parts in Space Program

Sounding rockets have many roles in the NASA space program. They are the only practicable vehicles for investigating space between the altitudes of 20 miles (maximum balloon altitude) and 150 miles where air drag quickly downs satellites. Sounding rockets also furnish a rapid vertical profile of space over a certain area or at a certain time, a feat which satellites, traveling horizontally, can hardly duplicate. Because they are relatively easy to handle and launch, sounding rockets can quickly become airborne for a low-altitude report on a specific unscheduled event such as a solar flare. Sounding rockets also test types of instruments, equipment, and power supplies intended for future satellites and launch vehicles.

Sounding Rockets and Geoprobes

A sounding rocket is a vertically or near vertically fired rocket that climbs no higher than 4,000 miles before returning to earth. Rockets that go beyond this altitude but still do not approach lunar or planetary distances are called geoprobes (typified by the P–21 electron density profile probe described earlier in this chapter). A craft rocketing past geoprobe distance is termed a lunar, planetary, or solar probe, according to its destination.

Secret of Universe Disclosed

Ultraviolet observations of certain stars, with instruments carried above the atmosphere by sounding rockets, showed only one—whose surface temperature is a relatively cool 12,000° F.—that behaves as our sun. The output of ultraviolet rays from the other "hot" stars suggests that helium gas is forming compounds such as helium hydride. Such action is contrary to fundamental laws of chemistry, that the element helium does not form compounds.

Additional ultraviolet data were collected on September 18 and October 4 by British-made Skylark rockets launched from Woomera, Australia. This is the first time ultraviolet observations have been made from above the atmosphere in the Southern Hemisphere.

Solar Flare Hazard Underscored

Satellite and sounding rocket data have increased recognition of the radiation hazard posed for manned space flight by solar flares. These solar storms hurl streams of charged protons into space at speeds of more than a thousand miles per second.

When analyzed, "solar beam" data provided by sounding rockets (see Chapter 4, "Fifth Semiannual Report") revealed that radiation dosage from a single flare in November 1960 would have been lethal to space travelers despite shielding. As a result, studies are being directed toward developing reliable methods for long-range forecasts of these flares so that earth-moon journeys can be scheduled for calm periods.

Upper Atmosphere Wind Studies

During September, NASA conducted a series of experiments at Wallops Station, Va., to obtain additional data on temperatures, velocities, directions, and densities of upper atmosphere winds. Such studies are particularly valuable in weather research, high-altitude aircraft, and launching of rockets.

NASA gained excellent data on day-to-night variation of winds by launch at dawn and dusk, on September 14, of Argo D-4 rockets. The rockets ejected orange-yellow sodium vapor about 120 miles and at 230 miles above the earth.

On September 16 and September 17, NASA launched Nike-Asp rockets with sodium and lithium vapor payloads. The orange-red vapors were injected into the atmosphere beginning at 38 miles. Vapor trails extended to an altitude of about 130 miles. French scientists participated in these experiments, held at Wallops Station.

The value of the experiments was enhanced by coordination with Italian Space Committee launches of sodium-vapor payloads at Perdas de Fogu, Sardinia. This marked another step toward determination of the existence and nature of upper atmosphere wind tides—similar to ocean tides.

Nike-Cajuns with payloads consisting of explosive charges were also launched on September 16 and 17 for comparison of their data with Nike-Asp vapor data. The charges were detonated intermittently from 20-mile to 40-mile altitudes. Information on wind temperatures and velocities was derived by timing the travel of sound waves from the rockets to ground stations.

The Nike-Cajun payload on September 16 also included a 4-foot diameter inflatable sphere which was ejected at an altitude of 50 miles. By observing air drag on its descent, a measurement of air density could be obtained.

The colorful sodium and lithium vapor payloads were visible for hundreds of miles from the launch site.

Solar X-Rays Observed Above Atmosphere

On September 30, NASA launched an Aerobee 150A rocket from Wallops Island to gather data on X-rays thrown out by the sun. The X-ray photometer—similar to that planned for the Orbiting Solar Observatory—was the first instrument of its type used above the earth's atmosphere.

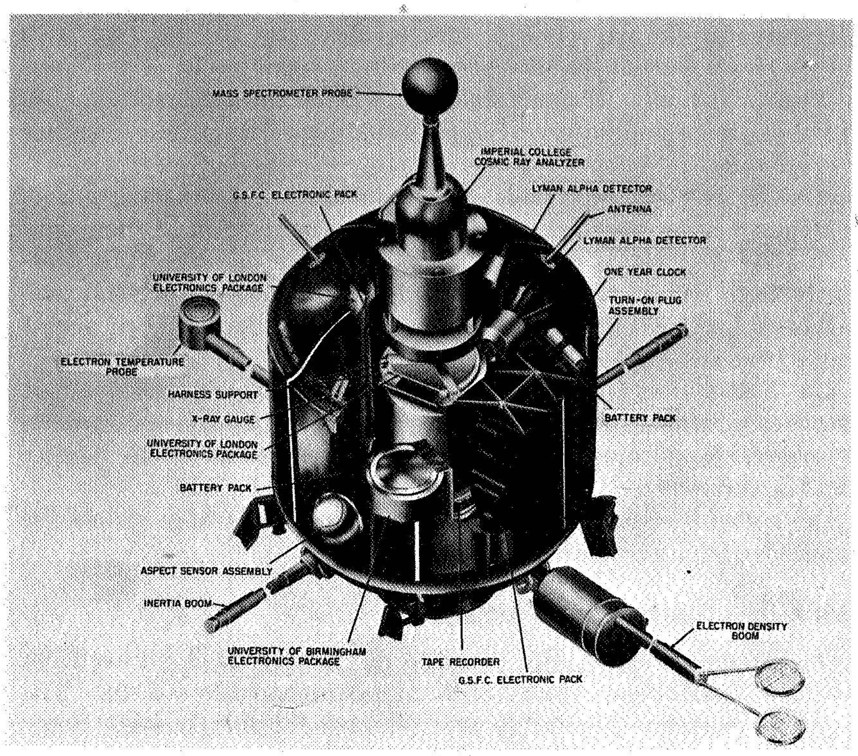
Study of Energetic Particles Over Northern Latitudes

During September NASA launched four Aerobee 100 rockets from Fort Churchill, Manitoba, Canada, chiefly to gather data on energetic particles at altitudes of about 40 and 50 miles. Rockets and instrumentation operated as programed. Results were under study as the period closed.

Ionosphere Studies

Increased understanding of the electrified levels of the atmosphere called "the ionosphere" may lead to improved worldwide radio communication and contribute to increased accuracy in tracking spacecraft. NASA is investigating the ionosphere by means of satellites, geoprobes, and sounding rockets. Typical sounding rocket experiments included the following:

An Argo D-4 fired from Wallops on October 10, to measure electron density and determine the relative proportions of electrically charged helium and hydrogen atoms. The rocket climbed to 585 miles.



International ionosphere satellite.

Nike-Cajuns launched on the nights of August 19 and October 27, to measure electron density and temperature of the ionosphere when the sun is not overhead. A similar experiment took place during daylight on December 8, 1960. Data were acquired at altitudes of 50 to 90 miles.

Three Nike-Apaches launched during July and August to gather information about magnetic fields, radiation, and density of the ionosphere up to 120 miles.

Test of Alouette Instrumentation

In October, NASA launched an Argo D-4 rocket from Wallops Station in a test of equipment to be used in the planned U.S.-Canadian Alouette satellite. This satellite will orbit above the ionosphere and gather information by bouncing radio waves from its surface.

Hydrogen Fuel Studies

On August 12 and October 18, Aerobee 150A's with liquid hydrogen and accompanying instrumentation were launched to study behavior of the fuel under the weightless condition of space. Such studies are vital to development of the Atlas-Centaur, Saturn, Advanced Saturn, and Nova launch vehicles which are designed to use hydrogen-powered upper stages.

Atmosphere-Entry Research

A four-stage Trailblazer rocket was launched over Wallops on December 14 in an atmosphere-entry test. Such tests show entry heating effects on craft returning to earth from orbit. Two rocket stages boosted the vehicle to an altitude of about 167 miles and two others drove it downward through the atmosphere, reaching a peak velocity of about 14,000 miles per hour.

Table 1.—NASA Satellite and Probe Launchings, July 1, through Dec. 31, 1961

Name, date, site, lifetime, mission	Launch vehicle	Payload	Test results
EXPLORER XII (1961 Upsilon); Aug. 15, 1961, Ceased reporting Dec. 6, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* Place satellite in highly elliptical earth orbit. Investigate solar wind, interplanetary magnetic fields, distant portions of earth's magnetic field, energetic particles in interplanetary space and in the Van Allen belts.	DELTA. *Stages:* *1st:* Modified USAF Thor IRBM. *2d:* Liquid rocket with radio guidance. *3d:* Spin stabilized solid rocket. *Gross lift-off weight:* 112,000 lbs. (approximately). *Height:* 92 ft. *Base diameter:* 8 ft.	*Dimensions:* Approximately 27 in. diameter, 19 in. high, exclusive of protruding magnetomer boom and 4 solar cell paddles. *Total payload weight:* 83 lbs. *Instrumentation:* 10 experiments for measurement of protons and electrons and their relation to magnetic fields, optical attitude sensor, and 1 transmitter. *Transmitters:* 2 watts, 136.020 mc. *Power supply:* 5,600 solar cells, 13 silver cadmium batteries.	Orbit achieved; all instrumentation operating normally. *Period:* 26 hours, 25 minutes. *Orbital path:* Highly elliptical. *Launch inclination:* 33.3° to the Equator. *Velocities:* Perigee: 23,500 m.p.h. Apogee: 1,860 m.p.h. *Perigee:* 180 (miles). *Apogee:* 47,800 (miles).
EXPLORER XIII (1961 Chi); Aug. 25, 1961 (estimated 1 year). *Launched from:* Wallops Station, Wallops Island, Va. *Mission:* Place satellite in elliptical earth orbit. (1) Study performance, structural integrity and environmental conditions of Scout vehicle and guidance control system. (2) Investigate the nature of micrometeoroids and their effects on space flights.	SCOUT. *Stages:* *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled up version of 4th scale. *4th:* Altair—modified X-248 Vanguard 3d stage. *Gross lift-off weight:* 36,600 lbs. (approximate). *Height:* 72 ft. *Base diameter:* 40 inches.	*Dimensions:* 76 in. long, 24 in. diameter. *Total payload weight:* 187 lbs. including 50-lb. spent 4th stage and 12-lb. transition section. *Instrumentation:* Detectors: (1) Pressurized cells of various thicknesses. (2) Foil gages (printed circuit mounted underneath stainless steel samples). (3) Wire grids. (4) Cadmium-Sulfide cells. (5) Piezoelectric crystal impact detecting transducers. *Transmitters:* 2 separate transmitter-telemetry circuits, operating on 136.860 mc and 136.20 mc, respectively. *Power supply:* Solar cells and nickel cadmium batteries.	A faulty orbit (resulting from lower than desired perigee) caused the satellite to reenter the atmosphere on Aug. 28, 1961. The 3d to 4th stage separation system (since changed) deflected the 4th stage and satellite, producing a lower than planned perigee and the faulty orbit.
Mercury-Atlas IV (MA-4) (1961 Alpha-Alpha); Sept. 13, 1961 (1 hour, 49 minutes). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* Orbit unmanned spacecraft to test means of return to earth within preplanned recovery area after single orbit; test worldwide Mercury tracking net-	ATLAS D. *Gross lift-off weight:* 260,000 lbs. (approximate). *Height:* 93 ft., including spacecraft and escape system. *Base diameter:* 10 ft., excluding the booster.	*Dimensions:* 9 ft. 6 in. high; 6 ft. base diameter. *Total payload weight:* 3,900 lbs. (liftoff). 2,700 lbs. (in orbit). 2,200 lbs. (recovery). *Instrumentation:* Crewman simulator to test environmental control equipment; 2 voice tapes for check of tracking net-	Orbit and reentry achieved on a fully automatic basis. Spacecraft recovered from sea 161 miles east of Bermuda. Flight demonstrated spacecraft could sustain man in orbit, booster was capable of placing spacecraft in desired orbit and recovery forces could expeditiously retrieve spacecraft. *Period:* 88.3 minutes.

work. Place spacecraft in earth orbit and recover it.		work; automatic attitude sensing and control system; life support system; 3 cameras; 3 tape recorders; devices for recording vibration, acceleration and temperature. 6 radiation packs (emulsions). *Transmitters:* 2 UHF voice transmitters; 2 HF voice transmitters; C-band radar beacon; S-band radar beacon; HF/UHF recovery beacon; Ultra-SARAH rescue beacon. *Power supply:* Chemical batteries.	*Orbital path:* Equatorial orbit. *Launching inclination:* 32.57° to the Equator. *Velocity:* 17,500 m.p.h. (average). *Perigee:* 98.9 (miles). *Apogee:* 142.1 (miles).
Mercury-Atlas V (MA-5) 1961 Alpha Iota; Nov. 29, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* To orbit Mercury spacecraft carrying chimpanzee to test all Mercury systems.	ATLAS D. *Gross lift-off weight:* 260,000 lbs. (approximately). *Height:* 93 ft. high, including spacecraft and escape system.	*Dimensions:* 9 ft. 6 in. high; 6 ft. base diameter. *Total Payload Weights:* 4,100 lbs. (liftoff). 2,900 lbs. (in orbit). 2,400 lbs. (recovery). *Instrumentation:* 4 cameras, 6 radiation measurement packs, 86 temperature measurement instruments, 2 play-back tape recorders. *Transmitters:* 2 UHF voice transmitters; 2 HF voice transmitters; C-band radar beacon; S-band radar beacon; HF/UHF recovery beacon; Ultra-SARAH rescue beacon. *Power supply:* Chemical batteries.	Orbit achieved. Spacecraft commanded down after 2 orbits due to development of abnormal roll rate. *Period:* 88.5 minutes. *Orbital path:* Earth orbit. *Launch inclination:* 32.5° to the Equator. *Velocity:* 17,500 m.p.h. (average). *Perigee:* 99.6 (miles). *Apogee:* 147.5 (miles).
Mercury Scout I; Nov. 1, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* Place satellite in earth orbit to test Mercury tracking and communications facilities.	SCOUT. *Stages:* *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled up version of 4th stage. *4th:* Altair—modified X-248 Vanguard 3d stage. *Gross lift-off weight:* 36,600 lbs. *Height:* 72 ft. *Base diameter:* 40 in.	*Dimensions:* 12 x 12 x 17 in. *Total payload weight:* 150 lbs., to remain attached to spent 4th stage casing. *Instrumentation:* Transmitters and associated electronics. *Transmitters:* C- and S-band radar beacons, 2 telemetry transmitters, 2 command receivers, 2 minitrack beacons. *Power supply:* Chemical batteries.	Orbit not achieved. Launch vehicle deviated from planned flight path and was destroyed by Range Safety Officer after approximately 30 seconds flight.

Table 1.—NASA Satellite and Probe Launchings, July 1, through Dec. 31, 1961—Continued

Name, date, site, lifetime, mission	Launch vehicle	Payload	Test results
P-21 Probe; Oct. 19, 1961 (90 minutes (approximately)). *Launched from:* Wallops Island, Va. *Mission:* To test Scout vehicle and guidance systems; measure ionospheric electron density profile; and to test new Doppler Velocity and Position facility at Wallops Station.	SCOUT. *Stages:* *1st:* Algol. *2d:* Castor—a modified Sergeant motor. *3d:* Antares—scaled-up version of 4th stage. *4th:* modified X-248 Vanguard 3d stage. *Gross lift-off weight:* 36,600 lbs. (approximately). *Height:* 72 ft. *Base diameter:* 40 in.	*Dimensions:* 15 in. diameter; 33 in. high. *Total payload weight:* 94 lbs. *Instrumentation:* 2 transmitters. *Transmitters:* 12.627 mc (1 watt); 73.6 mc (0.5 watt). *Power supply:* Nickel cadmium batteries.	Probe achieved altitude of 4,261 miles and transmitted good data.
Ranger I (1961 Phi); Aug. 23, 1961 (estimated 2-4 weeks). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* Development of spacecraft systems for future lunar and interplanetary missions; investigate cosmic rays, radiation and dust particles in space, as well as whether earth is trailed by comet-like tail of hydrogen gas.	ATLAS-AGENA. *Stages:* *1st:* Modified Atlas D. *2d:* Agena B. *Gross lift-off weight:* 275,000 lbs. (approximate). *Height:* 102 ft. *Base diameter:* 16 ft. (maximum).	*Dimensions:* 5 ft. base diameter; 11 ft. long. *Total payload weight:* 675 lbs. *Instrumentation:* Experiments in solar radiation, particle detection, cosmic rays, magnetic fields, solar X-rays, neutral hydrogen geocorona, cosmic dust, and friction in space. *Transmitters:* One ¼-watt transmitter, one 3-watt transmitter, 960.1 mc and 960.05, respectively. *Power supply:* 8680 solar cells, 1 silver zinc battery, plus several smaller power systems.	Ranger placed in low earth orbit, rather than deep space orbit programmed. Primary objective, test of spacecraft, achieved. *Period:* 91.1 minutes. *Orbital path:* Circular earth orbit. *Launch inclination:* 32.90° to the Equator. *Velocities:* Perigee: 17,726 m.p.h. Apogee: 16,874 m.p.h. *Perigee:* 105.3 (miles). *Apogee:* 312.5 (miles).
Ranger II (1961 Alpha Theta); Nov. 18, 1961. *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* Development of spacecraft systems for future lunar and interplanetary missions; investigate cosmic rays, radiation and dust particles in space, as well as whether earth is trailed by comet-like tail of hydrogen gas.	ATLAS-AGENA. *Stages:* *1st:* Modified Atlas D. *2d:* Agena B. *Gross lift-off weight:* 275,000 lbs. (approximate). *Height:* 102 ft. *Base diameter:* 16 ft. (maximum).	*Dimensions:* 5 ft. base diameter; 11 ft. long. *Total payload weight:* 675 lbs. *Instrumentation:* Experiments in solar radiation, particle detection, cosmic rays, magnetic fields, solar X-rays, neutral hydrogen geocorona, cosmic dust, and friction in space. *Transmitters:* One 1¼-watt transmitter, one 3-watt transmitter. *Power supply:* 8,680 solar cells, 1 silver	Ranger placed in low earth orbit, rather than deep space orbit programmed. Primary objective, test of spacecraft, achieved. *Period:* 88.3 minutes. *Orbital path:* Earth orbit. *Launch Inclination:* 33.3° to the Equator. *Velocity:* 17,500 m.p.h. (average). *Perigee:* 94.9 (miles). *Apogee:* 145.7 (miles).

TIROS III (1961 Rho); July 12, 1961 (Established 3-4 months). *Launched from:* AMR, Cape Canaveral, Fla. *Mission:* (1) Developments towards satellite weather observation system; (2) obtain photos of earth's cloud cover for weather analysis; (3) determine amount of solar energy reflected and emitted by the earth. Place satellite in circular earth orbit.	THOR DELTA. *Stages:* *1st:* Modified USAF Thor IRBM. *2d:* Liquid rocket modified from Vanguard with radio guidance. *3d:* Solid rocket modified from Vanguard. *Gross lift-off weight:* 112,000 lbs. (approximate). *Height:* 92 ft. *Base diameter:* 8 ft.	zinc battery, plus several smaller power systems. *Dimensions:* 19 in. high; 42-in. diameter. *Total payload weight:* 285 lbs. *Instrumentation:* 2 wide-angle cameras, 2 tape recorders and electronic clocks, infrared sensors, 5 transmitters, horizon sensors. *Transmitters:* 2 TV cameras operating on 235 mc; infrared experiment transmitting on 237.8 mc, and 2 tracking beacons on 108 and 108.03 mc, respectively. *Power supply:* 9,260 solar cells, 63 nickel cadmium batteries.	Orbit achieved. Cameras and IR instrumentation transmitting good data. 1 camera system failed in late July; 2d camera and IR sensors provided excellent data for over 4 months. Many hurricanes and typhoons observed; Hurricane Esther discovered. *Period:* 100.4 minutes. *Orbital path:* Circular. *Launch inclination:* 48.1° to the Equator. *Velocity:* 16,700 m.p.h. (approximate). *Perigee:* 461.02 (miles). *Apogee:* 506.44 (miles).

CHAPTER 4

Unmanned Lunar and Interplanetary Programs

Spacecraft Supply Needed Data

NASA is developing unmanned instrumented spacecraft as trailblazers for manned space exploration. By preceding man to the moon and to other planets, such craft can provide vital information about unfamiliar environments; help determine favorable landing areas; and proof-test many of the systems to be used for manned journeys. Later, they could serve as supply or reconnaissance vehicles to support expeditions on other celestial bodies.

Until man himself can land on the moon or on other planets, NASA will utilize instrumented probes in a broad lunar and interplanetary program aimed at finding answers to fundamental scientific questions. These include: How did the solar system originate and evolve? Is there life elsewhere than on earth?

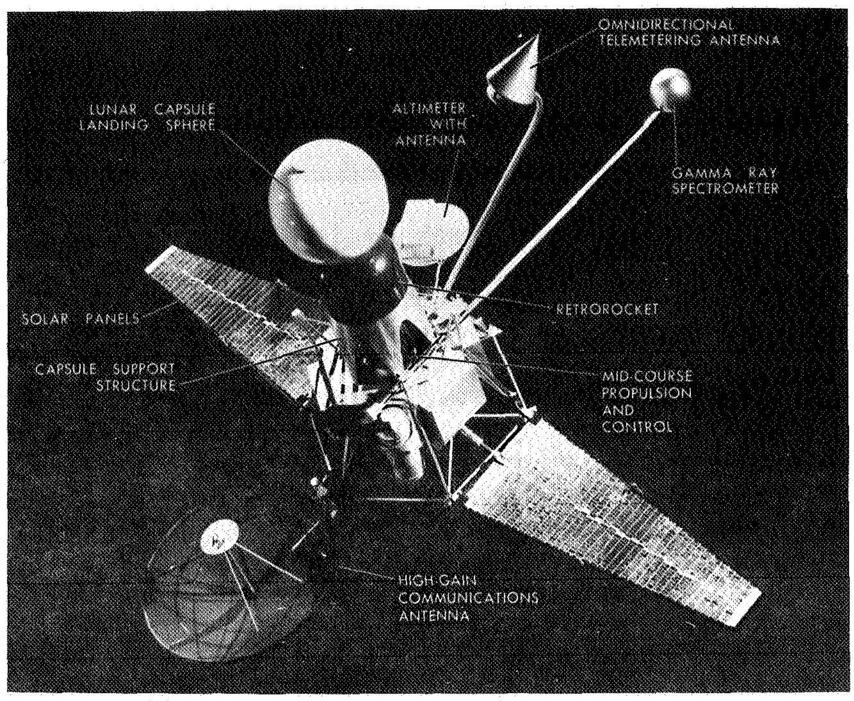
Moreover, during their long flights, instrumented craft would monitor interplanetary space—once conceived as a black empty void but since shown by earlier satellites and probes to contain energetic particles (electrified protons and electrons), cosmic dust, and other phenomena. Since solar radiation which controls earth's weather and affects radio communication must pass through this environment on its way to earth, knowledge of interplanetary space is fundamental to meteorology and communications engineering. Such knowledge would also contribute to planning for manned journeys.

NASA programs for unmanned exploration of the moon are termed Ranger, Surveyor, and Prospector, each of which is designed to furnish more exacting services than its predecessor. Interplanetary projects are Mariner and Voyager.

Ranger

Rangers I and II Launched

Agena B Malfunctions.—NASA launched Rangers I and II on August 23 and November 18, respectively. Malfunctions of the Agena B rockets during the second ignition phase stranded both spacecraft in low orbits ranging from 95 to 312 miles above earth. NASA had planned trajectories stretching 700,000 miles from earth primarily to permit a detailed check-out of systems to be used in future lunar and interplanetary flights.



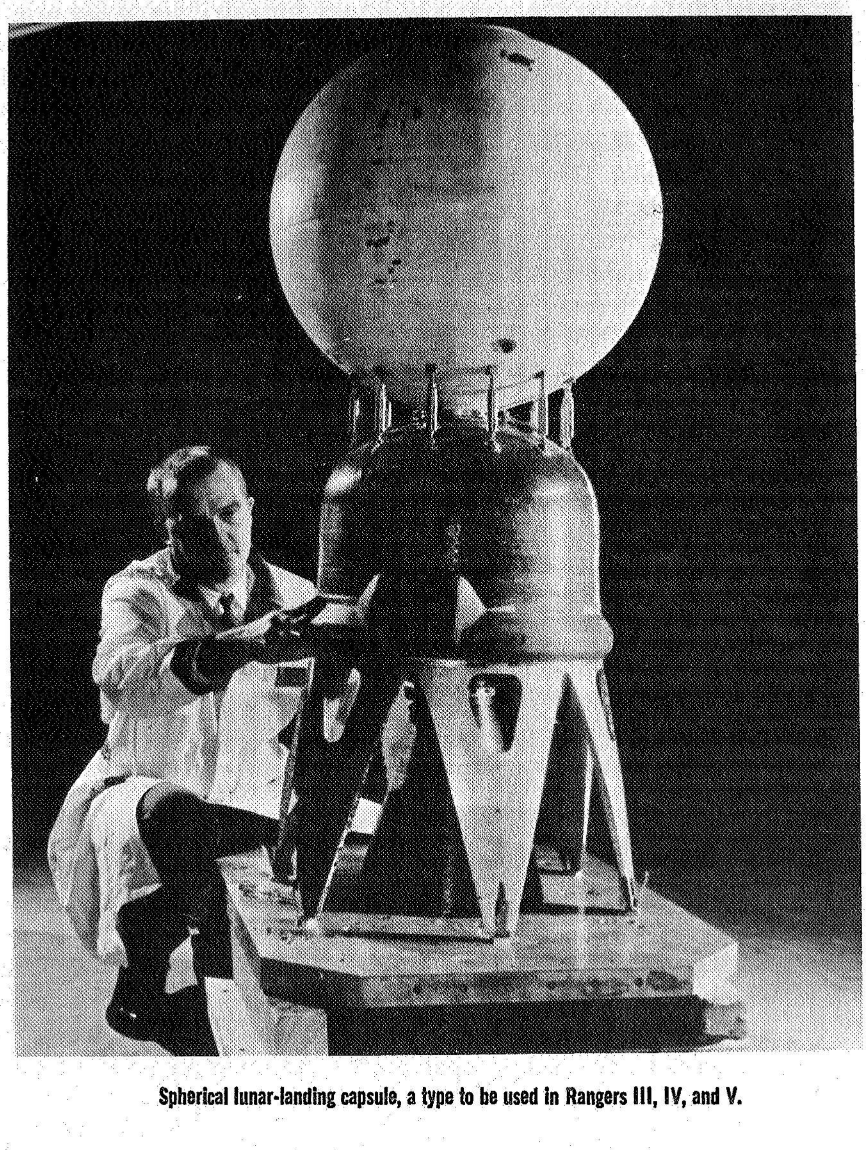
Ranger spacecraft with lunar capsule.

Ranger's Performance Encouraging.—Experimenters were able to conduct substantial checkout of systems despite the disappointing trajectory and were encouraged by both automatic performance of Ranger I[1] and its response to commands. For example, the fairing (protective covering for payload during launch) separated properly; Ranger's solar panels extended; its high gain communication antenna unfolded; and it executed commands sent to it by deep space instrumentation facilities (DSIF) on earth. Its unique attitude control system operated perfectly in sunlight, orienting Ranger so that its flat solar cell paddles faced the sun for power and the high gain antenna pointed to earth for communication. Its instruments gathered and transmitted information on radiation, cosmic dust, and magnetic fields along its orbital path. The value of this information was limited, however, because the experiments were designed for interplanetary space. Ranger I was in orbit about 1 week.

[1] Because of the brief orbital life (about 6 hours) of Ranger II, no control experiments were performed. Orbital and other detailed data on Rangers I and II appear in Table I, *NASA Satellites and Probes, July 1 through December 31, 1961.*

Rangers III Through V to Land Instruments

Ranger III Readied for Launch.—As the period ended, Jet Propulsion Laboratory was readying the craft for launch early in 1962. The approximately 750-pound Rangers III, IV, and V are designed to land survivable instrument packs on the moon. Ideally, about 25 miles from the moon, Ranger would eject a retrorocket-equipped instrument capsule. The retrorocket would decelerate the capsule from Ranger's lunar approach speed of 6,000 miles per hour to about 150 miles per hour before landing. (Ranger would crash at 6,000 m.p.h.).



Spherical lunar-landing capsule, a type to be used in Rangers III, IV, and V.

A crushable balsawood structure is wrapped around the capsule to cushion landing shock and protect the capsule's sensitive instruments. The capsule system, including retrorockets, protective materials, and instruments, weighs about 330 pounds. The instruments weigh about 56 pounds.

Capsule Contains Seismometer.—The primary instruments in the landing capsule are a seismometer and a radio transmitter to broadcast data for several months on disturbances in the moon's interior. Such disturbances would result from "moon quakes," meteorite impacts, or volcanic action. Data from lunar seismographs can provide a picture of the moon's interior which may furnish clues to the origin of the solar system—whether the planets were formed by condensation of interstellar dust or whether flaming chunks pulled from the sun by a near-collision with another star eventually cooled to become planets.

To Transmit High-Resolution Pictures.—The camera system employed in Rangers III through V is designed to transmit a picture every 13 seconds, aggregating 100 pictures during the lunar approach. The first, taken from an approximate altitude of 2,500 miles, will encompass a 25-square-mile area and show objects 650 feet across. The final picture will cover about 2,000 square feet and reveal objects 10 feet across (slightly larger than a full-size automobile). The best moon photographs by earth observatories distinguish features no smaller than about 2,000 feet. Ranger photographs will also be free from the distorting effects of earth's atmosphere.

Other Surface Data.—Data on other lunar surface characteristics would be obtained by radar reflectivity and gamma ray spectrometer readings during Ranger's descent. Gamma ray spectrometer experiments are aimed at determining whether the moon, like earth, has formed a crust which contains a relatively high concentration of natural radioisotopes. Such information would provide evidence on the moon's formation and heat balance and the possibility that chondrite meteorites, at least in part, come from the moon's surface. The radar experiment would provide information on the roughness of the lunar surface in the impact area and on lunar radar reflection properties.

Television System Contract Let

On July 24, NASA issued a letter contract to the Astro-Electronic Division of Radio Corporation of America (Princeton, N.J.) to develop and fabricate the high-resolution television system (including associated communication and electronic equipment) for the Ranger program. Jet Propulsion Laboratory (Pasadena, Calif.) will continue to construct the Ranger spacecraft. Aeroneutronic Division of

Ford Motor Company (Newport Beach, Calif.) is developing the survivable lunar landing capsule.

Four Rangers Added

On August 29, NASA announced an increase of planned Ranger launchings from five to nine. Each of the additional approximately 800-pound spacecraft will be equipped with six high resolution television cameras. The cameras will be programed to begin operating at about 800 miles above the lunar surface, where pictures will be equivalent in detail to those taken by earth observatories, and continue until moments before Ranger crashes. The final pictures should distinguish features no more than 8 inches across. About 1,600 photographs are expected from each craft. Rangers VI through IX would also monitor radiation data as they race toward the moon. They would carry no landing capsules. Principal purpose of these crafts is to support the accelerated program to land an American on the moon by 1970.

Surveyor

Soft Landing Craft Under Construction

Hughes Aircraft Company is constructing seven soft-landing Surveyors under NASA contract at its Culver City, Calif., plant. They are scheduled for launch by Atlas-Centaur from 1964 through 1966.

First Controlled Soft Landing.—Surveyor will be the first application of controlled soft-landing technology, perfection of which is essential to success of manned exploration. Surveyor's automatic landing system is designed to decelerate it from the lunar approach velocity near 6,000 miles per hour (9,000 feet per second) to touchdown speed of about 10 feet per second (approximately that of a passenger airliner).

To Transmit Photographs and Other Data.—Surveyor will have as much as 345 pounds of instruments to gather, analyze, and transmit information about the moon's surface and subsurface. Surveyor is designed to land on three legs, and operate its instruments as scientists on earth watch via television. It is equipped with four cameras and a high-resolution telescope to take pictures while Surveyor is dropping to the lunar surface, to scan the moonscape after landing, and to monitor equipment. This equipment includes a drill to pierce the moon's surface to a depth of several feet and a conveyor to transport samples of lunar soil to several instruments for analyzing their chemical composition. Other instruments are to measure physical characteristics such as bearing and shear strength of the lunar surface, constituents of the lunar atmosphere (if any), radiation, moon quakes,

656299 O—62——6

and magnetic fields. Surveyor is being designed to transmit data for a minimum of 30 days and as long as 90 days.

Could Reveal Important Information.—The information obtained through Surveyor is expected to advance knowledge about the moon's composition and internal structure and the origin of the moon and solar system. Instruments may also detect in the lunar dust organic substances that signify life, or prelife chemicals accumulated through natural processes over millions of years but not yet organized into living things. Such a find would be invaluable in the study of life processes.

Propellants Most of Takeoff Weight.—Takeoff weight of Surveyor will be about 2,300 pounds, the bulk of which consists of the rocket used for decelerating the craft for soft-landing. Other rockets on the craft will provide orientation prior to the landing maneuver and mid-course correction to assure interception of the moon. After landing, Surveyor will weigh about 750 pounds. It will actually weigh 120 pounds on the moon because of weaker gravity.

Lunar Orbiter To Be Built

During this period, NASA completed a study which established the feasibility of modifying the basic Surveyor soft-landing craft to produce a lunar-orbiting spacecraft. Development of the lunar orbiter is scheduled to begin in 1962.

The Surveyor lunar orbiter is intended for visual topographic reconnaissance, mapping the moon, and monitoring radiation and other space phenomena for about 6 months. Among its purposes are to help determine favorable landing areas for later unmanned and manned spacecraft.

Prospector

Preliminary Studies Completed

Preliminary studies of Prospector, conceived as a versatile space truck adaptable to a variety of advanced missions, were completed during the period. Engineering studies were scheduled for 1962. Prospector is being designed to reconnoiter the moon from low altitudes before landing. It would employ an advanced soft-landing technique based on that of Surveyor. The exceptionally heavy Prospectors are scheduled for launch in the second half of this decade by either Saturn C–1 or Advanced Saturn.

May Serve as Instrumented Laboratory

Prospector may land an unmanned mobile laboratory which scientists on earth will be able to guide over great distances to gather data. It could deliver a system for acquiring samples of the moon and rocketing them to earth for detailed study. It may also serve as a transport for resupplying astronauts on the moon or furnishing items from earth needed to establish a lunar base. Astronauts may use its remote-controlled mobile laboratory to broaden their area of exploration, particularly into territory that appears hazardous or is otherwise inaccessible.

Mariner

In the Mariner program, NASA plans to launch a series of unmanned spacecraft on trajectories passing as near as 17,000 miles to Mars and Venus. The chief purpose of these flights is to obtain scientific information on the nature of these planets—their surfaces, atmospheres, and fields. Of particular interest are questions relating to the existence of life.

During their approximately 3-month flights, the spacecraft are also expected to gather data on electrically charged particles (protons and electrons stripped from hydrogen atoms and constituting much of the radiation in space), cosmic rays (particles originating from the sun and stars and possessing extremely high radiation potentials), magnetic fields, and micrometeoroids (cosmic dust in space). Such information is expected to add significantly to scientific knowledge. It will also be valuable in preparing for the day when man journeys toward his planetary neighbors.

Mariner R

Components Being Assembled.—During the period, Jet Propulsion Laboratory was conducting final tests on and assembling components for the two Mariner R spacecraft scheduled for launch toward Venus in the summer of 1962. The primary purpose of these flights is to determine the surface temperature of Venus. The craft will also be designed to gather information on interplanetary space between earth and that planet.

Necessity for Meeting Schedule.—The first Mariners are to be launched to take advantage of the so-called Venus "launch window," a short time interval when minimum propulsion is required for the interplanetary journey. A given launch vehicle capable of firing a 1,300-pound spacecraft to Venus during the launch window could send no more than an 800-pound payload a month before or afterward. The Venus launch window occurs only once every 19 months. Two Mariner R launchings are planned to increase the chances of success in this difficult mission.

Mariner R Resembles Ranger.—Delays in Centaur development compelled NASA to substitute Atlas-Agena B for Atlas-Centaur in order to meet the launch window deadline in the summer of 1962. Atlas-Agena B can send a payload of about 460 pounds to Venus compared to the approximately 1,300 pounds which a perfected Centaur would have carried. Thus, NASA has had to reduce substantially the size and weight of the spacecraft originally planned for this experiment (Mariner A). The resulting craft resembles and employs much of the technology of Ranger, leading to the "R" designation.

Experiments Chosen.—NASA chose the following experiments for Mariner R:

(1) Microwave radiometer to provide information on the surface temperature of Venus and the composition of the Venus atmosphere.

(2) Infrared radiometer to provide surface and atmospheric temperature measurements.

(3) Fluxgate magnetometer, a highly sensitive instrument for measuring direction and intensity of magnetic fields in interplanetary space and around Venus. (In addition to its scientific value, such information may be important to design of reliable systems for communication over interplanetary distances.)

(4) Cosmic dust detector to determine density, speed, and direction of dust in interplanetary space.

(5) Electrostatic analyzer to measure the electrical charge and velocity of low-energy positively charged particles in interplanetary space.

(6) Ionization chamber and Geiger tubes to obtain the flux (rate of flow) and energies of energetic particles.

(7) Geiger counter to measure the flow of particles of intermediate energies.

Implications of Mariner R Experiment.—Measurements with radio telescopes on earth indicate that Venus has a temperature of 600° F. It is impossible from the earth, however, to distinguish whether this extreme temperature (which would make life as we know it impossible) exists on the Venus surface or in its ionosphere. From a vantage point within 20,000 miles of Venus, Mariner R infrared and microwave radiometers could provide more exact information about surface temperature and help determine whether conditions on Venus are favorable to life of some type.

Mariner B

Landing Capsule Under Consideration.—NASA is considering the addition of a landing capsule to Mariner B, a spacecraft intended for launch to the vicinities of Mars and Venus. The capsule, to be fired at the target planet as Mariner passes, would be programmed to transmit relatively simple data about the planet's surface and atmosphere. It may include a device to detect the presence of microbial organisms.

To Exploit Potential of Atlas-Centaur.—Mariner B will be as much as three times heavier than Mariner R, fully exploiting in terms of scientific payload the greater weight-lifting capability of the Atlas-Centaur launch vehicle. It will be instrumented to determine conclusively whether conditions on Mars or Venus are favorable to life. During the period, NASA selected a television camera system and radiometers as experiments for Mariner B and was considering others. The Mars launch window takes place only every 26 months; that of Venus, every 19 months.

Voyager

Voyager is the designation for a series of advanced spacecraft which NASA is considering as a follow-on of the Mariner experiments. In the last half of this decade, NASA intends to employ Saturn to launch the heavily instrumented Voyager which will contain complex guidance equipment for going into orbit about the target planet. As presently conceived, Voyager's high-resolution television cameras would peer down upon Mars or Venus while other instruments collect space evironmental data on atmospheres, magnetic fields, radiation belts, etc. In addition, Voyager may carry an instrumented capsule which would be dropped to the planet's surface and relay information to earth via the orbiting Voyager. Among other tasks, the capsule would attempt to confirm existence or absence of life by picking up and analyzing soil samples for chemicals unique to living organisms.

Tracking and Data Acquisition

Networks Operational

With completion in August of the South African deep space instrumentation facility, all NASA ground networks for tracking, communicating with, commanding, and acquiring data from spacecraft were operational. Plans call for modifications of the systems to support the expanded and accelerated space program set for the Nation by Congress and the President. Progress in implementing these plans and other significant developments relative to each network are described below.

Mercury Network

Readied for Manned Orbital Flight

The Mercury network flawlessly performed its mission during two orbital tests of the Mercury capsule: the unmanned single-orbit experiment of September 13 and the two-orbit flight with a chimpanzee on November 29. As the period ended, the network was alerted to cover America's first manned orbital flight, scheduled for early 1962.

Most Advanced of Ground Systems

Because a human life is at stake, the Mercury network must have reliable and redundant systems for contact with spacecraft. These permit nearly continuous ground control and monitoring of the capsule and medical observation of and voice communication with the astronaut. Data acquired by the worldwide stations are funneled into computers at Goddard Space Flight Center, where they are converted into usable information and flashed to Mercury Control Center (Cape Canaveral). All this occurs in what is called "real time," which means that the Control Center learns about events almost as soon as they occur.

The Mercury network is knit together by 100,000 miles of teletypewriter, 35,000 miles of telephone, and 5,000 miles of data circuits. Stations are located at: Cape Canaveral (installations at Grand Bahama and Grand Turk Islands are considered part of the Cape Canaveral station); Bermuda; a ship in the mid-Atlantic Ocean; Grand Canary Island; Kano, Nigeria; Zanzibar; a ship in the Indian

Ocean; Muchea and Woomera, Australia; Canton Island; Kauai Island, Hawaii; Point Arguello, Calif.; Guaymas, Mexico; White Sands, N. Mex.; Corpus Christi, Tex.; and Eglin, Fla.

Modifications Planned

Plans call for extensive modification of the Mercury network to meet the increased requirements of the scheduled 1-day Mercury orbital missions; the Gemini project to test man's reaction to space flights of a week or more and to practice joining craft in orbit; and Apollo orbital operations, the first of three steps to land Americans on the moon in this decade. These new projects stem from the nation's accelerated space program.

Satellite Network

High-Latitude Stations Operational

Construction of Minitrack stations at Fairbanks, Alaska, and St. Johns, Newfoundland, was completed during the period. These and stations built earlier at Winkfield, England, and East Grand Forks, Minn., permit NASA to cover satellites in polar and high-inclination orbits. (A satellite in polar orbit travels north to south around the world passing over the vicinities of the North and South Poles. One in a high-inclination orbit passes in part over areas in northern latitudes such as Great Britain and Canada.)

The Minitrack network, which maintains contact with unmanned earth satellites, comprises, in addition to those mentioned above, the following stations: Fort Myers, Fla.; Blossom Point, Md.; Goldstone, Calif.; Quito, Ecuador; Antofagasta, Chile; Santiago, Chile; Lima, Peru; Woomera, Australia; and Johannesburg, Republic of South Africa.

85-Foot Antennas Being Added

Until recently, NASA was limited by the capacity of its launch vehicles to small satellites containing relatively few experiments. With larger vehicles such as the Agena B series available, NASA is preparing multipurpose satellites to provide from a single orbiting station a large quantity of observations. (The Orbiting Geophysical Observatory, for example, will be able to carry as many as 50 different experiments.) To acquire the heavy flow of data from such complex craft, NASA is adding 85-foot-diameter antennas to the Minitrack network.

NASA completed the first of these at Fairbanks, Alaska, in December. The parabolic surface of this massive instrument can capture faint and diffuse signals and focus their energies on sensitive receivers.

The dish-shaped antenna rotates on two movable axes to follow a satellite from horizon to horizon. A consideration in building any installation of this sort is to isolate it from extraneous signals generated by commercial radio stations, transmission lines, and industrial machinery. The Fairbanks facility is located in a bowl-shaped wooded valley which tends to insulate it from such disturbances.

In November, NASA chose a site in the Pisgah National Forest for another 85-foot antenna. A tract near Rosman, about 40 miles southwest of Asheville, N.C., has been set aside for the facility. Advantages of the area are its natural shielding from radio interference, absence of air traffic, and accessibility. NASA selected Van Storch and Burkavage, Philadelphia, Pa., as architect-engineers for the installation.

As the period ended, NASA was considering several locations in the Far East for a third ultra-sensitive 85-foot antenna.

Automatic Data Read-Out Equipment Installed

The installation of automatic data read-out equipment, touched upon in NASA's Fifth Semiannual Report, was continued during this period. The system is devised to improve reliability and production and reduce the possibility of human error.

Optical Instrumentation

Optical systems are the most accurate method of fixing positions of satellites and generally are used to backup or calibrate electronic trackers. Their chief limitation is that they can operate only during the hours of darkness.

The Smithsonian's Astrophysical Observatory at Cambridge, Mass., manages two optical systems in support of NASA satellite programs. One is a 12-station network of precision Baker-Nunn cameras; the other, a volunteer organization called Moonwatch composed of teams using relatively simple telescopic equipment.

During this period, analysis of data on Explorer IX gathered by the optical network disclosed significant scientific information on air density in space near earth. (See Chapter 3, "Geophysics and Astronomy Programs.") The radio of Explorer IX failed soon after launch rendering electronic data-gathering techniques inoperative.

During this period no modifications were made in optical systems. The Baker-Nunn stations are located at: Organ Pass, N. Mex.; Woomera, Australia; Mitaka, Japan; Arequipa, Peru; Curacao, Netherlands West Indies; Villa Dolores, Argentina; Olifantsfontein, Republic of South Africa; Cadiz, Spain; Naini Tal, India; Shiraz, Iran; Jupiter, Fla.; and Maui, Hawaii.

Deep Space Instrumentation Facilities

With completion in August of the Hartebeesthoek facility near Johannesburg, Republic of South Africa, NASA gained the capacity for continuous line-of-sight communication with lunar and interplanetary probes despite the earth's rotation. Other deep space tracking stations are at Woomera, Australia, and Goldstone, Calif. The network was first exercised in the Ranger I and II experiments. (See Chapter 4, "Unmanned Lunar and Inter-Planetary Programs.")

Larger Diameter Antenna Being Considered

During the period, NASA completed reviewing competitive feasibility studies by four companies on 200- to 250-foot-diameter antennas which will be needed to acquire data from advanced lunar and planetary exploration programs, such as Prospector, Voyager, and Apollo. In August, NASA's Jet Propulsion Laboratory contracted with one of the four, the Blaw Knox Company (Pittsburgh, Pa.) for second phase feasibility and design studies of an antenna in this class. Plans call for the first of these antennas to be operational at Goldstone, Calif., by early 1965.

Experimenters anticipate that these large antenna systems will triple the current range of deep space instrumentation facilities. The antennas may multiply as much as tenfold the quantity of information that can be acquired from a spacecraft without increasing its size or weight. This would be accomplished by redesigning the spacecraft.

Wallops Station, Va.

The Wallops Station network is a relatively small version of the national ranges. This self-contained network includes radar and telemetry antennas, communication lines, and a computer center where data is fed and processed into a form useful to experimenters.

Construction of a new control center for all operations and installation of a 60-foot diameter antenna were among modifications to improve services. During the period the Wallops Station systems supported sounding rocket and geoprobe experiments (see Chapter 3, "Geophysics and Astronomy Programs") and Scout research and development flights. Wallops Station also serves as one of two read-out stations for the TIROS weather satellites. (The other is at Point Arguello, Calif.)

Launch Vehicle Programs

Booster Program Pace Quickens

NASA quickened its pace on several fronts to meet the time schedules set in the President's Statement to Congress on May 25. The Agency added Titan II to its launch vehicle fleet, made progress in the Scout improvement program, assigned the reliable Delta booster a major role as a launch vehicle, and made plans for more extensive use of the Air Force-developed Thor-Agena B and Atlas-Agena B. In addition, NASA successfully ground tested the RL–10 engine for the Atlas-Centaur and erected the first Atlas-Centaur on the launch complex at Cape Canaveral. (NASA launch vehicles are listed in table 2, p. 89).

The highlight of NASA's accelerated progress in developing a fleet of launch vehicles for space exploration was the highly successful test flight performance on October 27, of S–I, the Saturn C–1 first stage. The S–I, the Nation's most powerful booster, will have a key role in orbiting the Apollo spacecraft.

NASA also advanced its launch vehicle development programs by deciding upon the principal features of Advanced Saturn and Nova and by selecting sites for building, testing, and launching these vehicles.

Titan II Added to Civilian Space Program

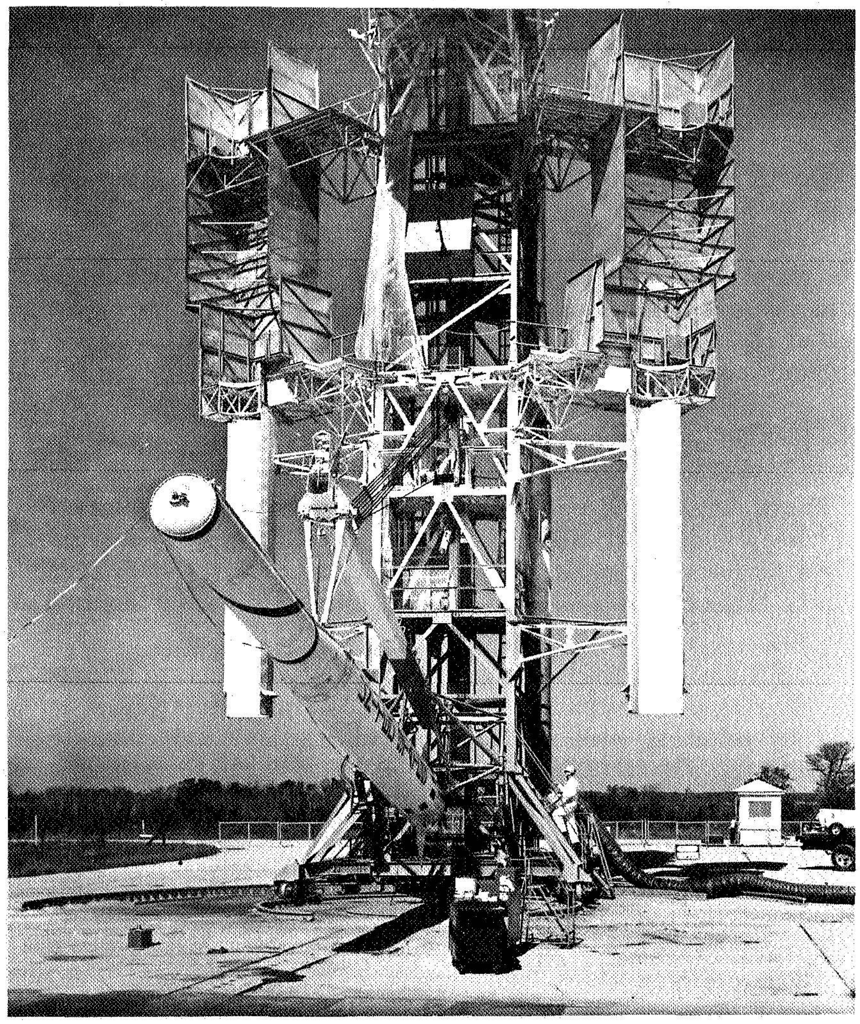
On December 7, NASA selected the U.S. Air Force Titan II as the most efficient launch vehicle for the Gemini spacecraft.

The first flight test is scheduled for March 1962. Meanwhile, captive firing tests in which the engine is started but the vehicle is not launched were continued during the period.

Titan II utilizes a new type of room-temperature liquid fuel designed for indefinite storage in the rocket's fuel tanks. Thus, unlike other liquid-propellant rockets whose fuel must be held at cryogenic (intensely cold) temperatures, Titan II can be fueled well ahead of a scheduled launch and need not be drained of fuel if a launch is postponed.

Scout

NASA and the Department of Defense employ Scout for space probe, atmosphere-entry, and satellite experiments.



Scout being readied for launch.

Two Developmental Flights Successful

During the period, NASA conducted two successful Scout launches at Wallops Station, Va. On August 25, Scout developmental vehicle No. 6 placed the Explorer XIII micrometeoroid satellite into orbit.

On October 19, Scout developmental vehicle No. 7 hurled the P–21 ionosphere probe to an altitude of more than 4,200 miles. (See Chapter 3, "Geophysics and Astronomy Programs.") Scout has performed satisfactorily in four of seven developmental launches to date.

Improvement Program on Schedule

The Scout improvement program, which involves incorporation of superior solid propellants and modification in design, is moving ahead. When this program is completed, Scout will be able to lift 240 pounds into orbit (it now fires 150 pounds). The program also involves improving Scout's launch operations and increasing its accuracy in launching satellites into predesignated orbits.

Additional Scouts Ordered

During the period, NASA and the Department of Defense ordered 10 Scouts, increasing the total on order to 30. The contractor has scheduled production of one Scout biweekly, beginning in January 1962.

New Launch Site Being Built

NASA is building a new launch site for Scout at Point Arguello, Calif. When completed in the spring of 1962, it will be used to launch small satellites southward into polar orbits. Wallops Station and Cape Canaveral, the other Scout launch complexes, launch satellites eastward to avoid populated areas to the north and south.

Delta

Delta launched the TIROS III weather satellite on July 12 and the Explorer XII energetic particles satellite on August 16 (See Chapter 3, "Geophysics and Astronomy Programs") increasing to five its string of successful launchings.

Assigned Major Space Role

NASA's Fourth Semiannual Report to Congress described Delta as an interim launch vehicle that would not be used after 1961. Delta's demonstrated reliability and its relatively low cost have altered that decision. On October 23, NASA authorized Douglas Aircraft Corporation to fabricate 14 Deltas, increasing to 26 the total to be used as launch vehicles for the TIROS weather satellites, the Telstar, Relay, and Syncom communications satellites, and several scientific satellites.

Thor-Agena B and Atlas-Agena B

Thor-Agena B and Atlas-Agena B launch vehicles, developed by the U.S. Air Force, have also been adapted to NASA programs.

Has Stop-Restart Ability

The Agena B upper stage engine can be stopped and restarted in space. Thus, ground personnel can cut off the Agena B motor after it is in orbit and, while the Agena B coasts, calculate the refiring point to attain a desired precise trajectory.

First Thor-Agena B Readied

NASA's first Thor-Agena B is being prepared at Point Arguello, Calif., to launch Echo II, the rigidized and enlarged successor to the Echo I passive communications satellite. NASA plans to use Thor-Agena B vehicles for launching scientific and other applications satellites requiring circular polar orbits; examples are the Nimbus meteorological satellite and the *P*olar *O*rbiting *G*eophysical *O*bservatory (POGO).

First Atlas-Agena B Vehicles Launched

On August 23 and November 18, Atlas-Agena B attempted to boost the Ranger lunar spacecraft into a highly elliptical orbit that would have carried it more than a half million miles into space. In both instances, the Atlas performed as planned, but the Agena B upper stage engine failed to restart. Studies were undertaken to prevent repetition of the restarting failures. Future Atlas-Agena B launches of Ranger will attempt to place the spacecraft on the moon.

Atlas-Agena B Has Wide-Ranging Space Role

NASA also plans to use Atlas-Agena B in (1) advanced communication, meteorological, and scientific satellite programs; (2) Project Gemini rendezvous experiments in which the target will be an unmanned Agena B rocket stage launched into orbit by an Atlas booster; and (3) the Mariner program, to launch (until the Atlas-Centaur vehicle is available) an instrumented spacecraft to Venus.

Lockheed Missiles and Space Company is producing 22 Agena B stages for NASA. Of these, 16 will be mated with Atlas D and 6 with Thor.

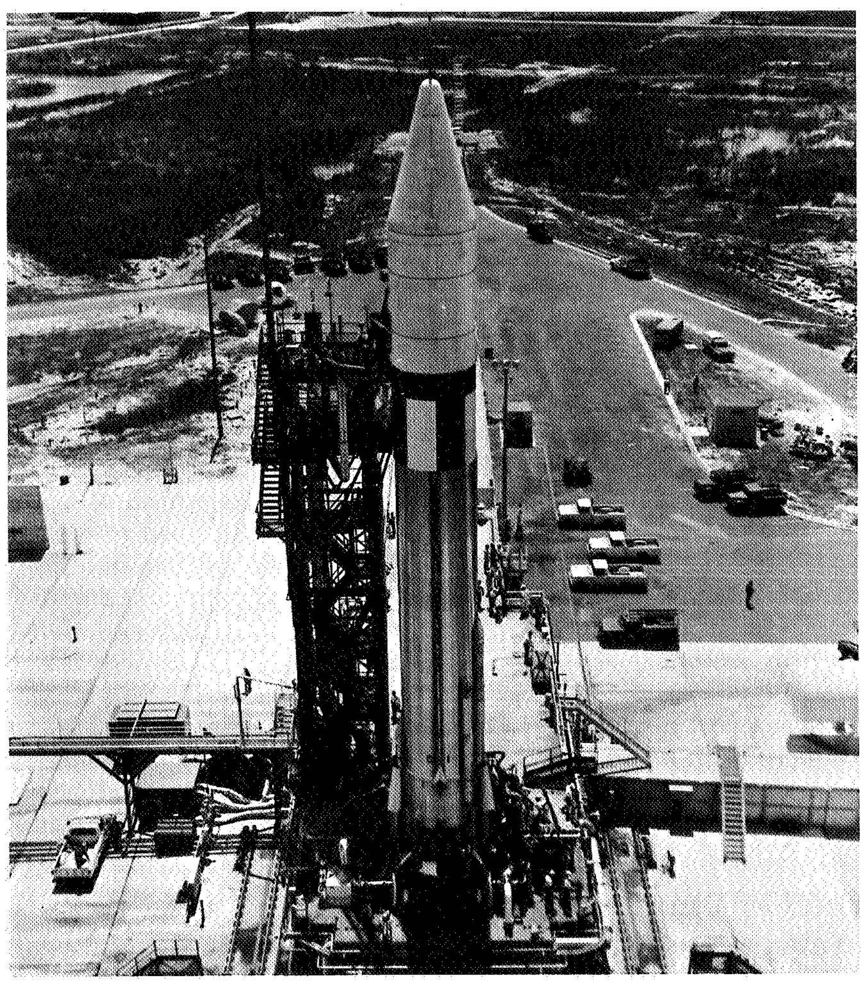
Atlas-Centaur

First U.S. Engine Burning Liquid Hydrogen

The Atlas-Centaur launch vehicle uses a modified Atlas as the first stage and the two-engine liquid oxygen (LOX)-liquid hydrogen burning Centaur as the second or upper stage. The high-energy liquid hydrogen when used with LOX provides about 40 percent more thrust than the same weight of such conventional propellants as refined kerosene and LOX.

Engine Exceeds Specification Requirements

The RL–10 hydrogen-fueled engine of Centaur passed its preliminary flight rating test (qualifying it for experimental flight) on November 12, after 20 successful ground firings. In the same month, two RL–10 engines, clustered to simulate operating conditions, were successfully fired for 30 seconds. The engine was also fired successfully in the high-altitude-simulation wind tunnel at NASA's Lewis Research Center. The performance of RL–10 in these and other tests during the period has exceeded specification requirements.



Atlas-Centaur on launch pad at Cape Canaveral, Fla.

First Atlas-Centaur at Cape Canaveral

In early November, the first Atlas-Centaur was erected on complex 36, one of the two Centaur launch complexes at Cape Canaveral. Prelaunch tests were in progress as the period ended.

Engineers Studying Fuel Tank Insulation

Engineers are studying improved methods of insulating the vehicle's fuel tanks to keep the extremely cold liquid hydrogen from boiling away in flight. Significant boilaway could seriously retard Centaur's ability to perform its mission. Several promising insulating methods are being evaluated, and efforts are concentrated on solving mechanical problems associated with insulation.

Has Major Unmanned Lunar and Interplanetary Role

NASA plans to use Atlas-Centaur to launch its heaviest unmanned spacecraft such as Mariner B and Surveyor. Experience in Centaur development and operation should contribute to progress in development of liquid-hydrogen liquid-oxygen powered upper stages for Advanced Saturn and Nova launch vehicles.

Saturn C–1

S–I Launch Successful

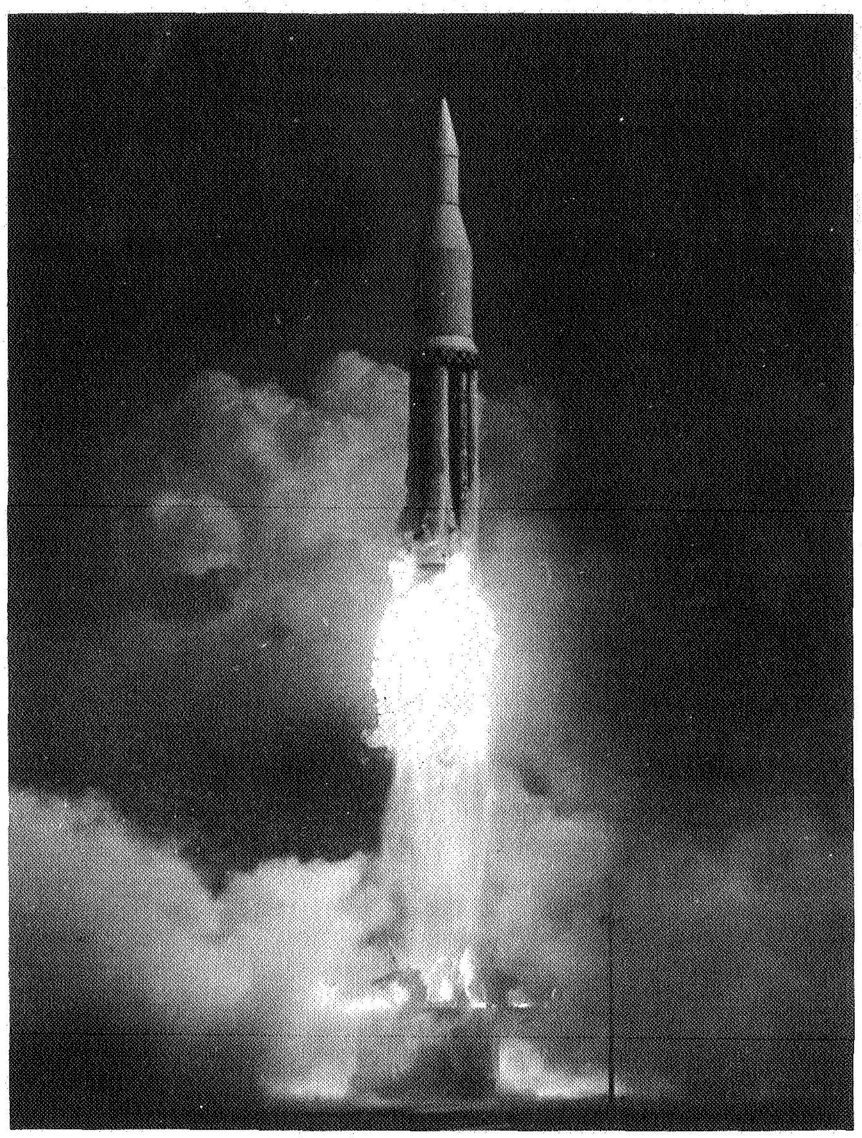
A near-perfect performance was given by S–I, the first stage of Saturn C–1, in its first test flight on October 27. Takeoff thrust of the eight-engined S–I was 1.5 million pounds. The launch vehicle reached a maximum altitude of 84.8 miles and a top speed of 3,607 m.p.h. during engine burning time of 115 seconds. It fell into the Atlantic Ocean 214.7 miles downrange from Cape Canaveral 8 minutes 3.6 seconds after launch. The trajectory nearly coincided with that programed.

This flight was the climax of 3 years of effort by NASA's team at the Marshall Space Flight Center. It demonstrated that a cluster of eight reliable liquid-propelled engines could yield controllable high thrust and that the vehicle's control system and structure could meet the demanding criteria of performance. It proof tested the Saturn C–1 launch complex and launch operations.

Research and Development Flights to Continue

NASA has scheduled a total of 10 Saturn C–1 research and development flights. Goals are for the engines to reach rated thrust levels and to attain 99 percent reliability in full-duration firings.

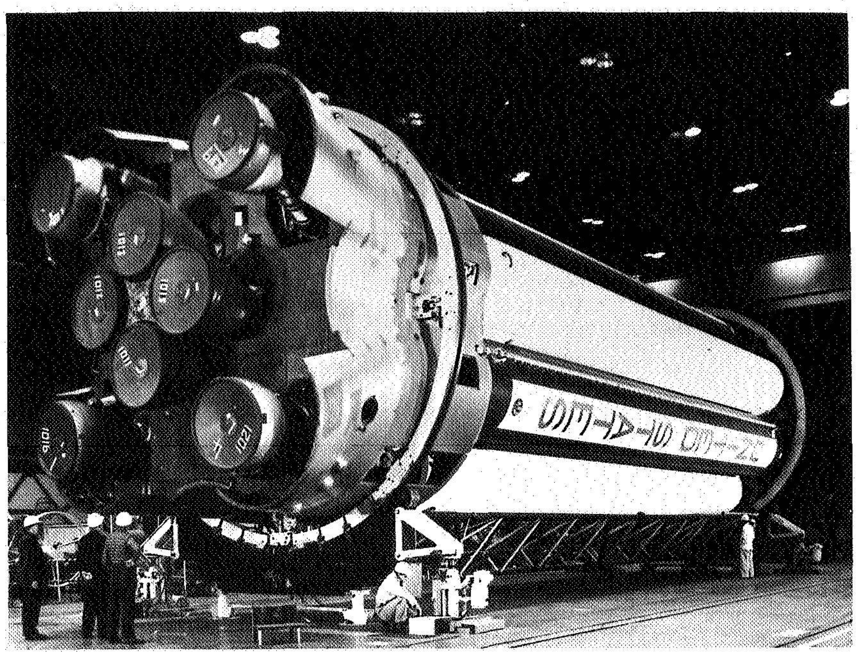
SA–1, as the first Saturn flight test vehicle was designated, carried two water-filled upper stages as ballast, reflecting the original Saturn



First successful launching of Saturn from Cape Canaveral.

C–1 design. Three additional S–I's, constructed to accommodate two upper stages, are too far ahead in production to be changed and still meet time schedules; consequently, they too will be tested with two dummy upper stages. The fifth research and development Saturn C–1 will consist of the redesigned booster (S–I) stage and a single upper stage.

656299 O—62——7



Saturn C–1 first stage being prepared for October 27, 1961, flight test.

Second Saturn is Flight Qualified

Marshall Space Flight Center fired SA–2, the next research and development Saturn to be flown from Cape Canaveral, for about 30 and 115 seconds in two static (ground) tests during October. These qualified Saturn for flight test. Its shipment by barge from Marshall to Cape Canaveral is expected early in 1962.

Third Flight Vehicle Being Assembled

As the period ended, Marshall Space Flight Center was assembling SA–3, the third research and development Saturn. Static tests to qualify SA–3 for flight test are scheduled to be carried out in the first half of 1962.

Design changes of Saturn C–1, described in the Fifth Semiannual Report to Congress, were being incorporated in the vehicle during the period. By December 31, NASA completed redesign of the second stage and studied the possibility of using the Centaur upper stage as a Saturn C–1 third stage (in other than Apollo missions). Redesign of the first stage moved ahead, and completion was targeted for mid-1962.

S–IV Development Progresses

S–IV is the liquid-hydrogen liquid-oxygen fueled upper stage of Saturn C–1. It consists of six RL–10 A–3 Centaur engines, each of which generates 15,000 pounds of thrust. By December, the engine contractor had delivered three engines to the S–IV contractor.

During the period, the contractor fabricated the first full-scale test S–IV and began tanking tests in which liquid oxygen, liquid nitrogen, and ultimately liquid-hydrogen are pumped into and drained from the S–IV at varying flow rates. Cold flow testing, which simulates operation except for actual combustion, is expected to begin early in 1962. "Hot," or firing, tests will follow.

Materials for insulating the S–IV fuel tank to prevent boil-away of the very cold liquid hydrogen were tested, and two seemed promising. One is made up of end-grain balsa; another, of polyurethane plastic foam and glass fibers.

Contract Let for Operational S–I

On November 17, NASA announced its intent to negotiate a contract with the Chrysler Corporation to build, check out, test, and launch operational S–I boosters. Chrysler will build the S–I's at NASA's newly acquired Michoud Plant, and ground test the stages at NASA's new Static Test Facility near the mouth of the Pearl River in Mississippi.

Marshall Space Flight Center will continue to assemble and test S–I stages for the research and development program.

Advanced Saturn

In December, NASA decided on the so-called C–5 version of the Advanced Saturn, leapfrogging over two other concepts called C–3 and C–4.

The C–5 would employ five F–1 engines in the first stage, providing a takeoff thrust of 7.5 million pounds; five J–2 engines in the second stage, generating total altitude thrust of 1 million pounds; and a single 200,000-pound thrust J–2 engine in its third stage. It would be able to place more than 200,000 pounds in low earth orbit or send an 80,000-pound spacecraft to the vicinity of the moon.

Will Have Multiple Uses in Apollo Program

The Advanced Saturn will be a versatile and flexible launch vehicle available for multiple uses in the Apollo program. It will first be used to accelerate the Apollo command module to escape velocity (about 25,000 m.p.h.—the speed at which lunar or interplanetary spacecraft enter or leave the earth's environment) in order to test the module's ability to withstand the severe heating and deceleration accompanying entry into the earth's atmosphere. The command module, one of three Apollo sections, may be likened to the passenger and crew compartments of an airliner. It is the only part slated to return to earth.

The Apollo spacecraft for circumlunar flight will weigh substantially less than that for manned landing because it will not have the multi-ton lunar-landing (braking) and lunar takeoff rockets. This consideration prompted design of the Advanced Saturn first stage so that two engines can be removed without impairing operation. This simpler version of Advanced Saturn provides ample power for the Apollo circumlunar mission. Its first stage has a thrust totaling 4.5 million pounds, and it could place a payload of about 120,000 pounds in earth orbit or launch a 40,000-pound spacecraft to the moon.

NASA's preferred method for orbital rendezvous leading to landing of men on the moon is to join only two craft in earth orbit. For this mission, the Advanced Saturn would use five engines in its first stage and a single upper stage—the 1-million-pound-thrust cluster of five J–2 engines normally constituting its second stage. This two-stage Advanced Saturn can put a 200,000-pound payload into a 300-mile earth orbit.

For orbital rendezvous, one Advanced Saturn would launch a fully fueled rocket stage into orbit. After ground telemetry established the rocket's orbit and indicated that the rocket's condition was satisfactory, a second Advanced Saturn would orbit the manned Apollo spacecraft, including its auxiliary propulsion units (lunar landing, lunar takeoff, and mid-course correction rockets). The Apollo astronauts would pilot their craft to a junction with the rocket stage; and, at the optimum point in orbit, the rocket stage would be ignited, launching Apollo to the moon.

Other Possible Uses

The Advanced Saturn powered by three F–1 engines in its first stage could be used to launch large unmanned space probes to the moon or the planned Voyager to Mars and Venus. (See Chapter 4, "Unmanned Lunar and Interplanetary Programs.") Another possibility is the use of this vehicle to achieve manned lunar landing by rendezvous of spacecraft in *lunar* orbit.

Contractor for First Stage Selected

On December 15, NASA announced that it would negotiate a contract with the Boeing Company, Seattle, Wash., to design, develop, and produce the first stage—designated S–IB—of the Advanced

Saturn. Boeing was selected from among 27 firms invited to submit proposals.

Boeing will conduct most S–IB work at NASA's Michoud Plant where the first stage of Saturn C–1 will also be produced. Boeing's Wichita, Kans., and Seattle plants will also participate. Captive firings of S–IB will be carried out at Marshall Space Flight Center until test stands are ready at NASA's Mississippi Test Facility.

S–IB will be 33 feet in diameter and about 140 feet long. It will hold about 2,250 tons (562,500 gallons) of refined kerosene and liquid oxygen propellant.

Work Begins on Second Stage

Development of S–II, the second stage of the Advanced Saturn, began during this period. On September 12, NASA selected the Space and Information Systems Division of North American Aviation, Inc., to design, develop, and fabricate S–II. The S–II will be 33 feet in diameter (the same as S–IB) and 70 feet long. Its five J–2 engines, providing a total thrust of 1 million pounds, are fueled by high performance liquid hydrogen and liquid oxygen. The S–II carries 400 tons (100,000 gallons) of propellant. The stage will be so constructed that if one engine fails, the others will consume its fuel with little loss in stage performance. This so-called "engine-out capability" contributes greatly to reliability.

North American plans to fabricate components at Downey, Calif.; assemble them in a Navy facility at Seal Beach, Calif.; and static (ground) test the stage at its Santa Susana tests stands near Chatsworth, Calif.

Third Stage Modified

A single hydrogen-powered 200,000-pound-thrust J–2 engine is replacing the six 15,000-pound-thrust RL–10–A3 engines of the Advanced Saturn third stage. On December 20, NASA made an agreement with the contractor, Douglas Aircraft Company, to modify this stage. One of the structural changes required is to lengthen the stage from 42 to 63 feet in order to accommodate the 100 tons (25,000 gallons) of fuel for this stage. The diameter, 18½ feet, remains unchanged. Douglas will design, fabricate, and ground test the stage, redesignated S–IVB.

Nova

To accomplish the Apollo lunar-landing mission with a single launch (without rendezvous), NASA will need a rocket significantly larger than Advanced Saturn. NASA has had such a rocket concept—termed Nova—under study for several years. During this period, NASA settled on the major features of Nova.

Nova will be based on liquid-propulsion engines but will allow for the possibility of substituting solid-propellant rockets for the first stage. Nova's first stage will use eight 1.5 million-pound-thrust F–1 engines. It will hold about 4,000 tons (a million gallons) of refined kerosene and liquid oxygen. The second stage will cluster four M–1 engines for a total thrust of about 4 million pounds. The M–1, generating 1 million pounds of thrust, will be fueled by about 100 tons (25,000 gallons) of high-performance liquid hydrogen and liquid oxygen. The first and second stages will each have a diameter of 50 feet. As in the Advanced Saturn, the second stage will be able to operate even if one engine fails. The third stage of Nova will be similar to the third stage of the Advanced Saturn.

Nova will be designed to launch an orbiting space station weighing more than 185 tons, a lunar spacecraft weighing 75 tons, and interplanetary spaceship weighing about 50 tons. With a nuclear upper stage, Nova could double its escape payloads.

Nova is a NASA alternative for launching Apollo on its lunar-landing mission if orbital rendezvous techniques are not perfected in time. Nova will also be required for manned exploration beyond the moon and may be the transport system for support of a large lunar base.

New Facilities Added

NASA moved swiftly to acquire and prepare facilities for developing, manufacturing, and launching the large launch vehicles. On August 24, the Agency announced that it was acquiring about 80,000 acres to the north and west of Cape Canaveral for launching of Advanced Saturn and Nova. On September 7, NASA selected the giant Government-owned Michoud Ordnance Plant for assembly of Saturn and Advanced Saturn vehicles. NASA is converting the 1.8-million square feet of inactive manufacturing space in the plant into the largest vehicle-assembly area in the United States.

On October 25, NASA announced that it would acquire about 13,500 acres of land on the Pearl River in Southwest Mississippi. On this sparsely settled area, the Agency plans to construct test stands for ground firings of the massive Saturn, Advanced Saturn, and Nova stages.

All three sites are connected by deep water channels which facilitate transportation of the giant rockets by barge.

Integrate-Transfer-Launch Concept

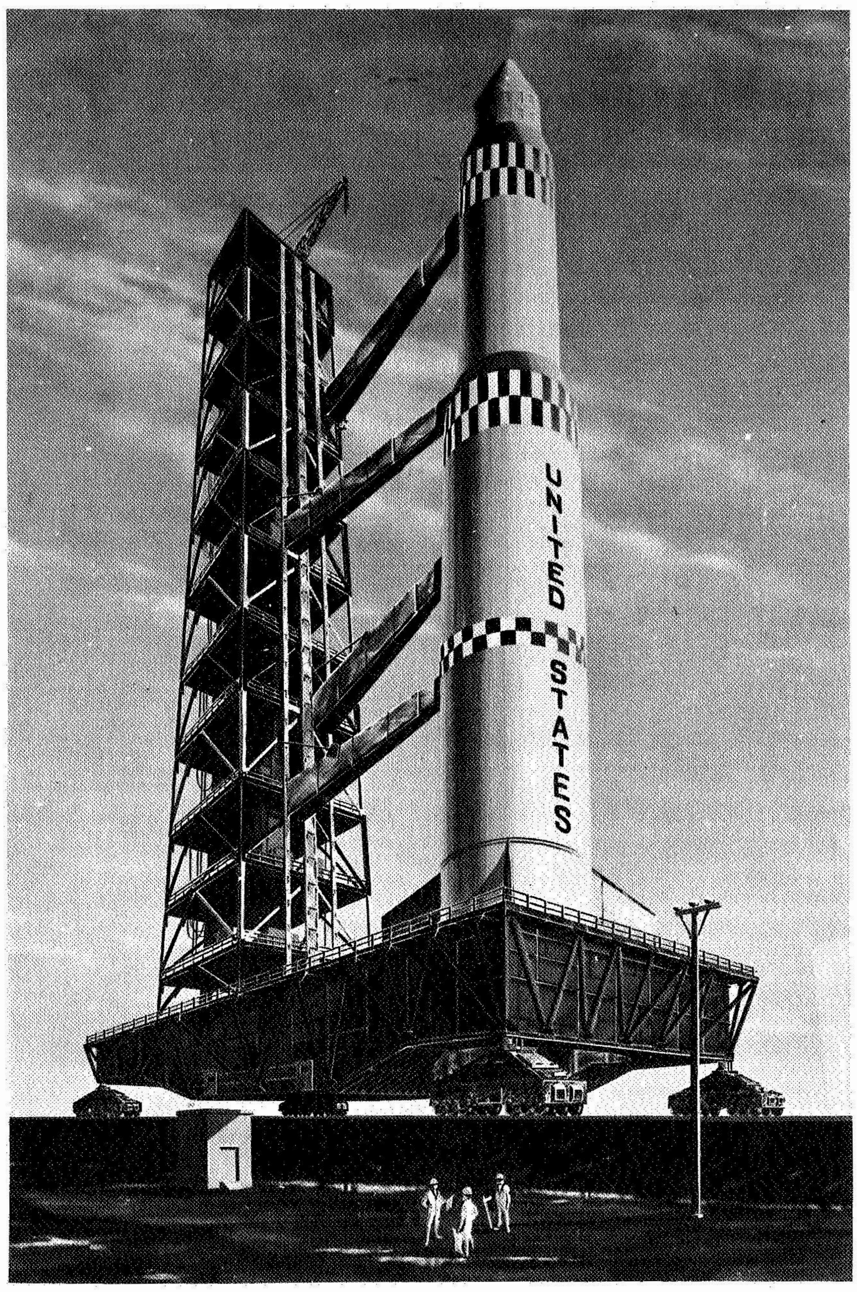
NASA is considering a concept termed "Integrate-Transfer-Launch" (ITL) for use in its new launch area adjacent to Cape

Canaveral. NASA would assemble and check out Advanced Saturns, for example, on mobile platforms in closed buildings some distance from the launch sites. Then, the platform carrying the Advanced Saturn would travel on rails to the launch area where the Advanced Saturn would be fueled, given a brief final checkout, and launched from the platform. The platform wouldl be renovated and reused.

Currently, launch vehicles are assembled at the launch site. The ITL concept offers the advantages of increasing the rate of launches from a single site and of facilitating assembly of large launch vehicles by sheltering the operation from inclement weather. With ITL, it might be possible to launch two or three Advanced Saturns monthly using only three operational launch pads.

Table 2.—NASA Launch Vehicles, Dec. 31, 1961

Vehicle	Stages	Payload capability in pounds			Principal use
		345 mile orbit	Escape	Mars/Venus	
Scout	4	150	----------	----------	Launching small scientific satellites and probes (Explorer).
Delta	3	500	60	----------	Launching scientific, meteorological, and communications satellites (TIROS).
Thor Agena-B	2	1,600	----------	----------	Launching scientific and applications satellites (Echo II, Nimbus, Unmanned Orbiting Geophysical Observatory).
Atlas D	1	----------	----------	----------	Launching manned spacecraft (Mercury); Centaur first stage.
Atlas Agena-B	3	5,000	750	400	Launching heavy communications and scientific satellites, lunar and planetary probes (Ranger, Mariner).
Titan II	2	----------	----------	----------	Launching manned spacecraft (Gemini).
Centaur	3	8,500	2,300	1,300	Launching heavy unmanned spacecraft for lunar and planetary probes.
Saturn C-1	2	20,000	----------	----------	Project Apollo.
Advanced Saturn (C-5).	3	200,000	80,000	60,000	Project Apollo.
Nova	3	375,000	150,000	100,000	Project Apollo.



Transporter and vehicle in ITL concept (artist's sketch).

Propulsion and Power Generation

Engine Research Progresses

In view of the increasing loads to be projected beyond the earth's atmosphere and the extended flights planned in the developing U.S. space program, NASA is continuing to attack propulsion problems on a high priority basis. During this reporting period (July 1–December 31, 1961) progress was made in developing three types of potentially reliable rocket engines: Chemical (liquid and solid); Nuclear (NERVA); and Electric (ion, arc-jet, and plasma).

The H–1 (hydrocarbon-oxygen) liquid-propelled engine, producing 165,000 pounds of thrust, was proven when used in a cluster of eight in the totally successful Saturn flight of October 27. The F–1 engine, designed to produce 1.5 million pounds of thrust, completed its initial static tests during July. Equally important was the successful completion of the Preliminary Flight Rating Test (in November) of the new liquid hydrogen-liquid oxygen second stage engines making up Centaur. A 73,000-pound motor using a solid propellant produced a thrust of 200,000 pounds when static tested; a two-segment version later produced over twice this power.

Prototypes of electric engines were tested that could produce a low but long-continuing thrust for upper stage use on very long space flights. Both the ion module and the arc-jet module proved satisfactory in experiments. Models of the electric plasma engine are still being fabricated for experimental testing in 1962.

During July the AEC–NASA Space Nuclear Propulsion Office—managers of the nuclear rocket propulsion program—contracted with Aerojet-General Corporation (Azusa, Calif.) for initial work in developing the first nuclear rocket engine based on technology developed in the Kiwi phase of Project Rover.

Liquid Propellants

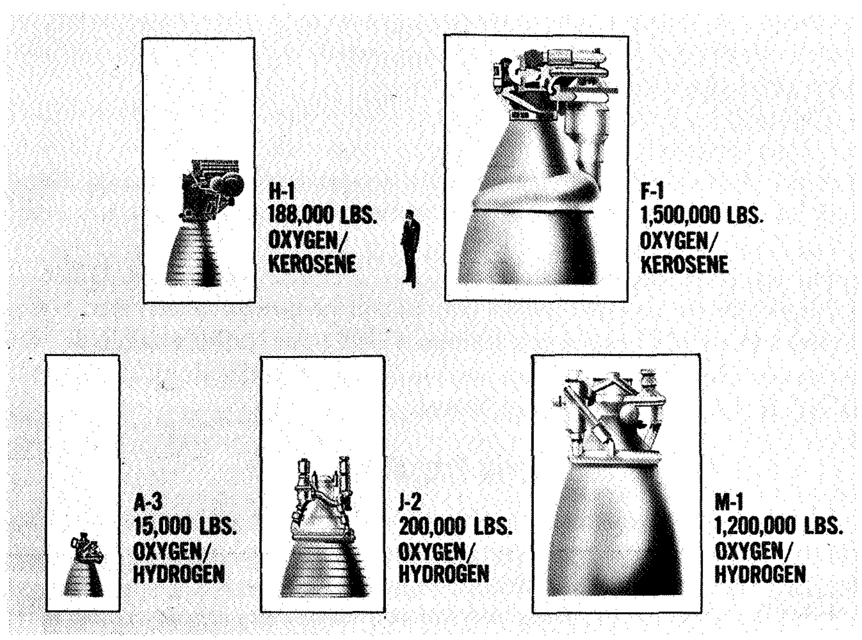
Liquid rockets continue as the major supplier of propulsion for space flight. Except for Scout—a four-stage, solid-propellant rocket that launched Explorer XIII on August 25—NASA's satellites were orbited by the liquid-propellant rockets Redstone, Thor, Atlas, and Delta. These liquid engines, burning a mixture of kerosene and liquid oxygen (LOX), produce about 240 pounds of thrust per pound of fuel per second.

NASA is now concentrating on research and development for higher energy propellant combinations such as liquid hydrogen and LOX which produce about 400 pounds of thrust. Engines so fueled have been tested for upper stage vehicles. The larger liquid engines under development, H–1 and F–1, will be clustered for increased launching capacity of NASA's giant rockets, the Advanced Saturn (C–3) and Nova.

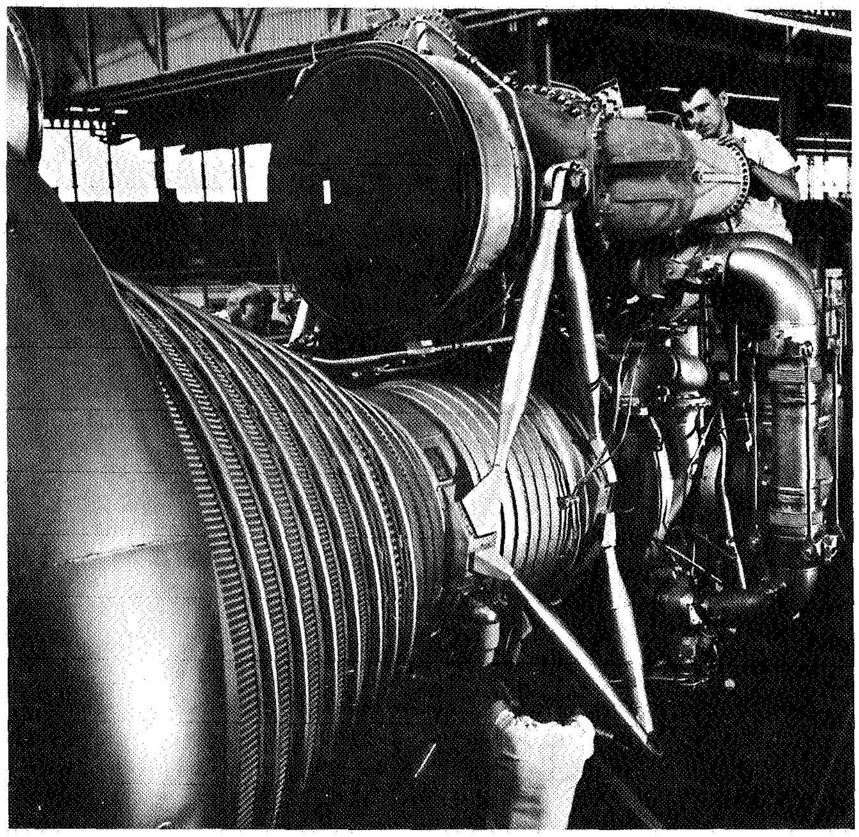
The F–1 Engine

Designed to produce 1.5 million pounds of thrust, the F–1 began operating during the report period as this country's most powerful liquid rocket engine. It is an enormous single-chamber rocket using LOX and RP–1 (a hydrocarbon refinement of kerosene). The Rocketdyne Division of North American Aviation, Inc. (Santa Susana, Calif.) contracted in January 1959 to develop this engine for NASA within fifty months after the start of the project.

Initial Testing Stage.—When the new rocket testing facility at NASA's Flight Research Center, Edwards Air Force Base (Calif.) was activated in June 1961, the F–1 engine had reached its initial testing phase. The Rocketdyne firm has tested five complete engines



Engines for manned flight.



The 1.5-million-pound-thrust F-1 engine.

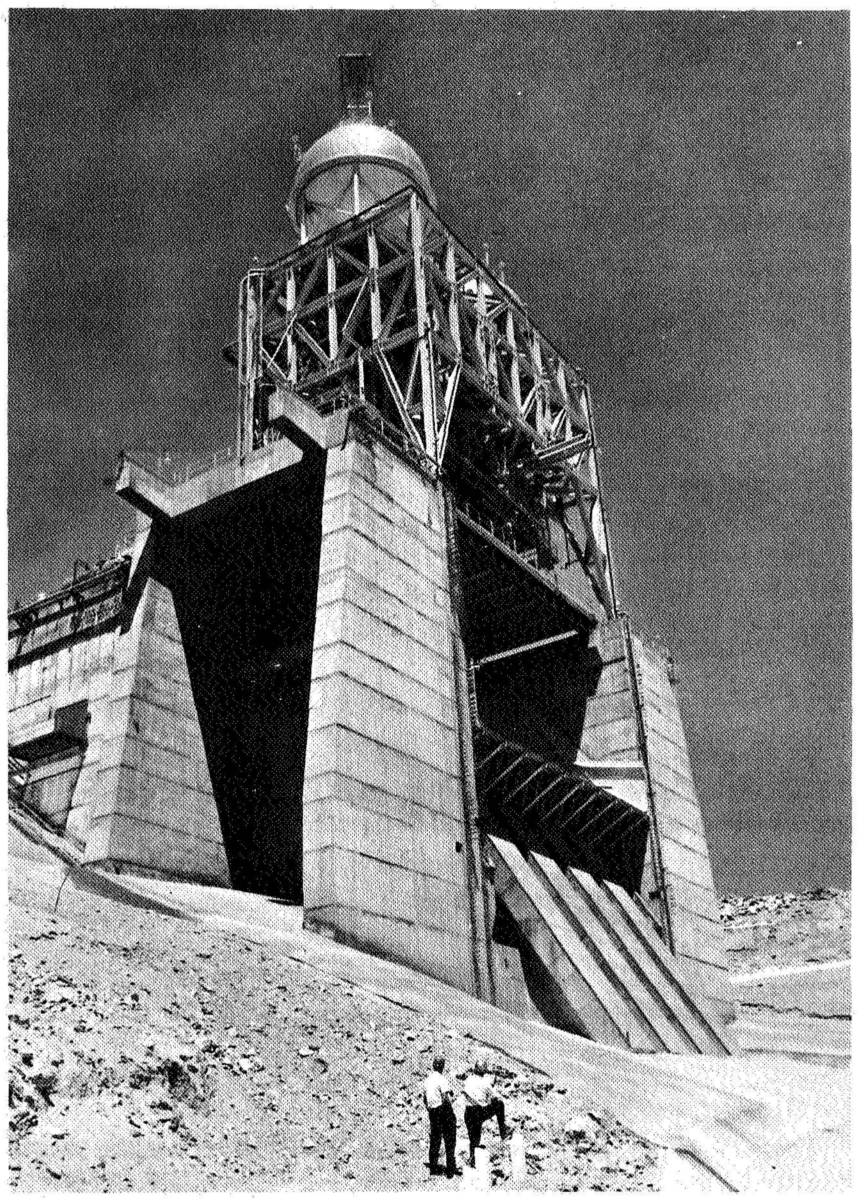
at the Flight Research Center, achieving a maximum thrust of 1.6 million pounds.

This testing phase is scheduled to culminate in a Preliminary Flight Rating Test (PFRT) by mid-1963, after which the F-1 can be considered qualified for experimental launch use.

J-2 Hydrogen-Oxygen Engine

The complex checkout tests of major components for the single-chamber, liquid hydrogen-liquid oxygen J-2 engine (See Chapter 7, "Propulsion and Power Generation," Fifth Semiannual Report to Congress), continued during 1961.

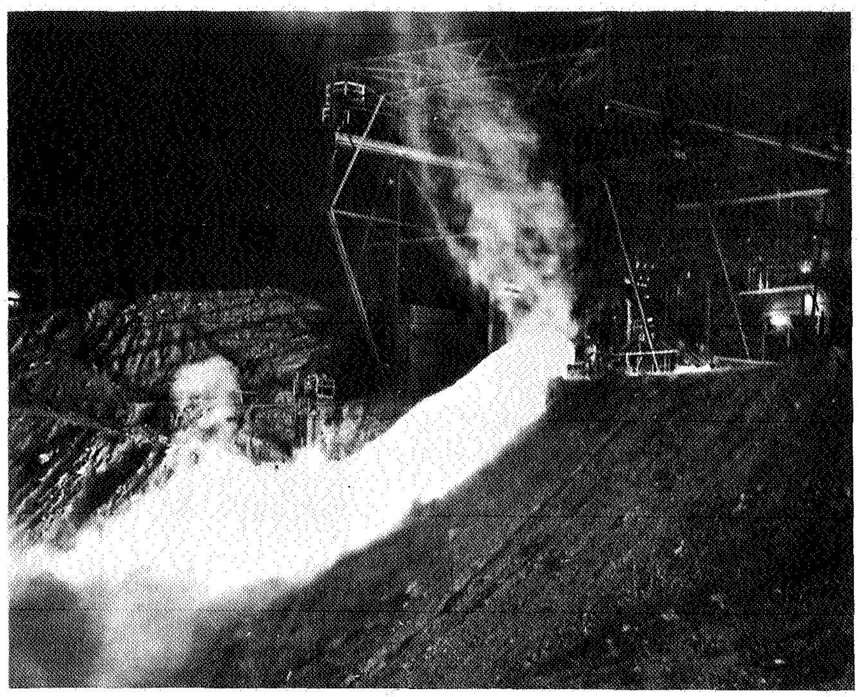
By the middle of December the tested components of this 200,000-pound thrust engine, for clustered use in an Advanced Saturn second stage, were considered sufficiently developed to permit their assembly by the Rocketdyne Division into the first complete J-2 engine—scheduled for its initial firing test early in 1962.



F-1 engine ground test stand.

Centaur's Engine

On November 4 the Centaur engine—first in the United States able to burn high-energy liquid hydrogen-liquid oxygen instead of the lower performing refined kerosene-liquid oxygen—successfully com-



The F-1 liquid rocket engine undergoes static tests.

pleted its extensive Preliminary Flight Rating Test at the West Palm Beach (Fla.) research and development center of the Pratt and Whitney Division of United Aircraft Corp.

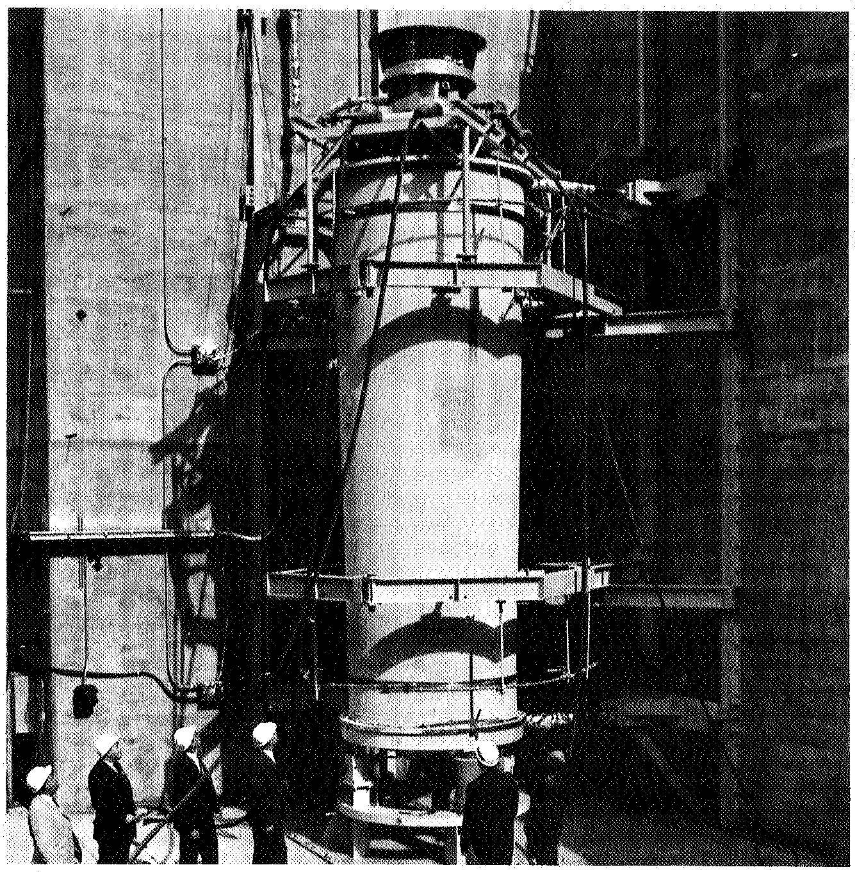
NASA plans to use this engine to launch heavy unmanned instrumented probes to the Moon, Mars, and Venus.

Designed to produce 15,000 pounds of thrust and for use in clusters as the second stage booster of an Atlas or Saturn launcher, the Centaur engine has been shipped for assembly into its vehicle stage for a first flight from Cape Canaveral in the spring of 1962.

Solid Propellants

Although the majority of this country's space vehicles have been launched by liquid propulsion engines, solid propulsion systems have been used for Scout and for various sounding rockets. Accordingly, during 1961 NASA continued its moderate support of research and development on solid propellants.

Solid boosters use the least energetic fuel, realizing 245 pounds of thrust per second per pound of fuel against 300 to 450 pounds of thrust from liquids.



A 73,000-pound solid rocket awaiting static test.

However, solid propellant rocket motors have certain inherent advantages. Able to remain in a stand-by status for long periods and still be ready for almost immediate firing, they are also easily handled and their prelaunch procedures relatively simple.

Further, in addition to high reliability in launchings, their developmental periods are generally briefer than those for other propulsion systems.

Major activities in NASA's investigations of various solid motors from July 1 through December 31, 1961 are outlined in the following paragraphs.

Small Solid Motors

Scout.—As further proof of its reliability the four-stage solid propellant Scout launched the Explorer XIII Micrometeoroid Satellite from Wallops Island, Va., on August 25, and on October 19, carried the P-21 electron density profile probe to an altitude of about 4,261 statute miles impacting it almost 4,424 statute miles from Wallops.

Advanced Design Sounding Rocket.—Atlantic Research Corp. (Springfield, Va.), under contract with NASA, has completed testing components for a 200-pound Archer sounding rocket engine, measuring 7 inches in diameter.

As a result of these successful initial tests the Naval Research Laboratory has organized a program to develop a sounding vehicle to use this motor of advanced design. Flight tests are scheduled during 1962.

Multilayer Engine.—The Allegany Ballistics Laboratory of the Hercules Powder Co. (Cumberland, Md.) has developed and satisfactorily test fired a multilayer engine.

Solid propellant in layers between rubber binders comprises almost 95 percent of the 600 pounds of this motor's weight—representing one of the most efficient designs tested.

Large Solid Motors

United Technology Corp. (Sunnyvale, Calif.) carried out a successful static test firing of a 73,000-pound, single fuel-chamber solid propellant motor for NASA on August 5.

Producing over 200,000 pounds of thrust, the 27-foot long tapered, segmented motor—86 inches in diameter—burned for 70 seconds.

The company's follow-up test of a 140,000-pound, two-segmented version of the motor, under NASA-Air Force agreement, resulted in the production of 500,000 pounds of thrust for 80 seconds on December 9.

Aerojet-General Corp. (Sacramento, Calif.) completed testing of a similar motor, on August 26, also attaining 500,000 pounds of thrust for 47 seconds.

As a result of these tests NASA has asked the two contractors to design solid motors 120 and 240 inches in diameter for possible use individually or in clusters to power launch vehicles for lunar flights.

Research With Solid Rockets

Liquid Metal to Cool Engine's Nozzle.—Rocketdyne Division of North American Aviation, Inc. (Canoga Park, Calif.) has contracted with NASA to produce a lightweight nozzle-cooling system for solid-propellant motors by spraying liquid lithium onto the back of a molybdenum alloy nozzle.

The 6,000° F. heat generated by burning gases in the engine's exhaust as they provide the motor's thrust has always been a major problem of solid propellants. This liquid-metal cooling method promises to reduce the engine's weight and at the same time allow nozzles to stand up under temperatures greater than the 7,000° F. expected to be generated by future solid fuels.

Simplified Steering Systems.—A steering technique for very large solid boosters was perfected by United Technology Corp. (Sunnyvale, Calif.), when a 450,000-pound thrust solid-fueled engine was test fired on December 18.

The contractor tested a simplified steering mechanism developed by the Naval Ordnance Test Station at Inyokern, Calif.

Other "steering package" systems are being developed for NASA by: Allegany Ballistics Laboratory of the Hercules Powder Co., Vickers, Inc., a Division of Sperry Rand Corp. (Detroit, Mich.), and the Allison Division of General Motors Corp. (Indianapolis, Ind.).

Malfunction Warning Devices.—Maximum safety for occupants of solid-fueled spacecraft would be assured by the development of elaborate warning systems to indicate malfunctioning components, permit mission aborts, and allow escapes in an emergency.

Aerojet-General Corp. in September, and Thiokol Chemical Corp. (Huntsville, Ala.), in October, signed contracts with NASA to provide the basic information needed to design these safety systems.

Similar devices are now available for liquid rockets.

Studies of Rocket Noise.—An understanding of the effects of the unprecedented noise that could be created by future solid rockets generating 20-million pounds or more of thrust is needed before such large engines can be safely test fired and flown.

Whether the intense noise produced by these huge motors can injure a rocket's electronic and mechanical equipment, its propellant, or its structural materials, is being investigated for NASA by Conesco, Inc. (Arlington, Mass.) under a contract with the Agency signed in September.

Effects of Space on Solid Motors.—A solid propellant motor may be exposed to the vacuum, radiation, and temperature fluctuations of the space environment for weeks, months, or even years before it is required to operate.

Battelle Memorial Institute (Columbus, Ohio) has contracted with NASA to determine the possible effects of such adverse conditions on engines for solid rockets. Various types of propellants, igniters and igniter materials, and other rocket components will be tested by the Institute.

Nuclear Propulsion

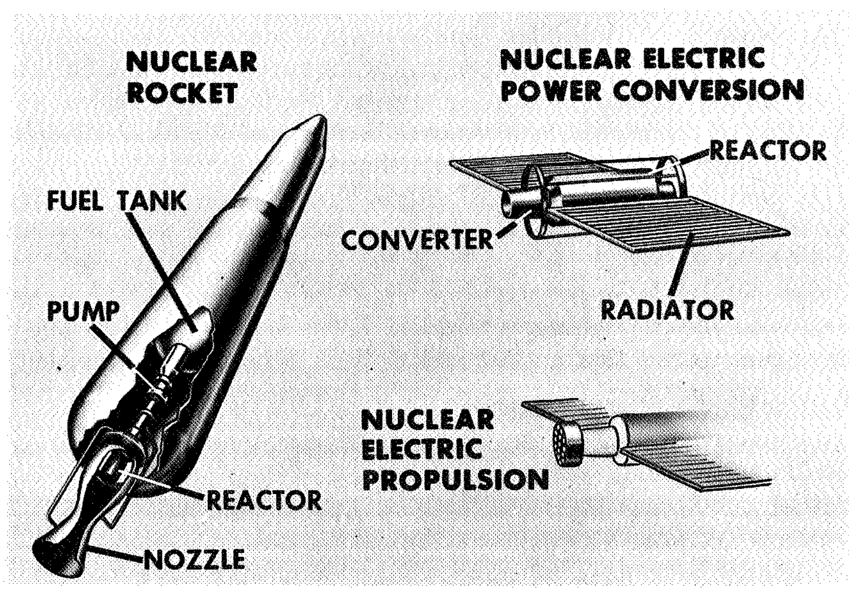
The Rover program, conducted by NASA jointly with the United States Atomic Energy Commission, has as its ultimate aim the development of nuclear rocket systems for space exploration. Nuclear rockets have significant advantages over chemical rockets, particularly for longer space missions. For example, the substitution of a nuclear-rocket engine for a chemical engine in the third stage of the Advanced Saturn vehicle could make possible a manned lunar landing and return mission without rendezvous and docking in orbit.

Progress Made in Kiwi Reactor Tests

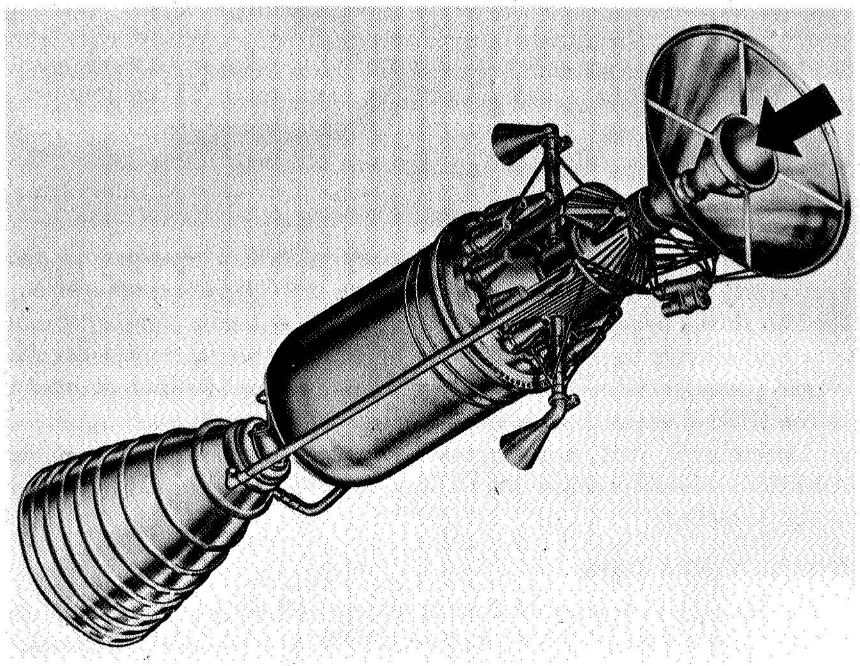
The Los Alamos Scientific Laboratory (LASL), operated by the University of California under contract to AEC, has been developing for the Rover program a series of nonflyable reactors (named Kiwi) as a preliminary to the development of a flyable reactor. During the report period, this work progressed. The testing of the first reactor in the Kiwi-B series (the latest series to be developed) was completed on December 7, 1961, using gaseous hydrogen as the reactor coolant. Additional tests are scheduled to begin in 1962, using liquid hydrogen as the propellant.

Work on NERVA Begins

The initial phase of work for the design and development contract of the first nuclear rocket engine, NERVA (*N*uclear *E*ngine for *R*ocket *V*ehicle *A*pplication), was awarded to Aerojet-General Corp., July 10, 1961. Aerojet's principal subcontractor, Westinghouse Electric Corp., is undertaking the nuclear portion of the work, namely,



Nuclear systems technology.



NERVA engine, preliminary design.

development of the reactor for inclusion in the NERVA engine. This reactor is based on the design concepts being developed at LASL. This phase is scheduled for completion in January.

NERVA will ultimately be tested in an upper stage of a Saturn-class launch vehicle. According to plans, the flight-test vehicle will be lifted off the ground by a chemical booster, and NERVA will start during flight as the chemical booster finishes firing.

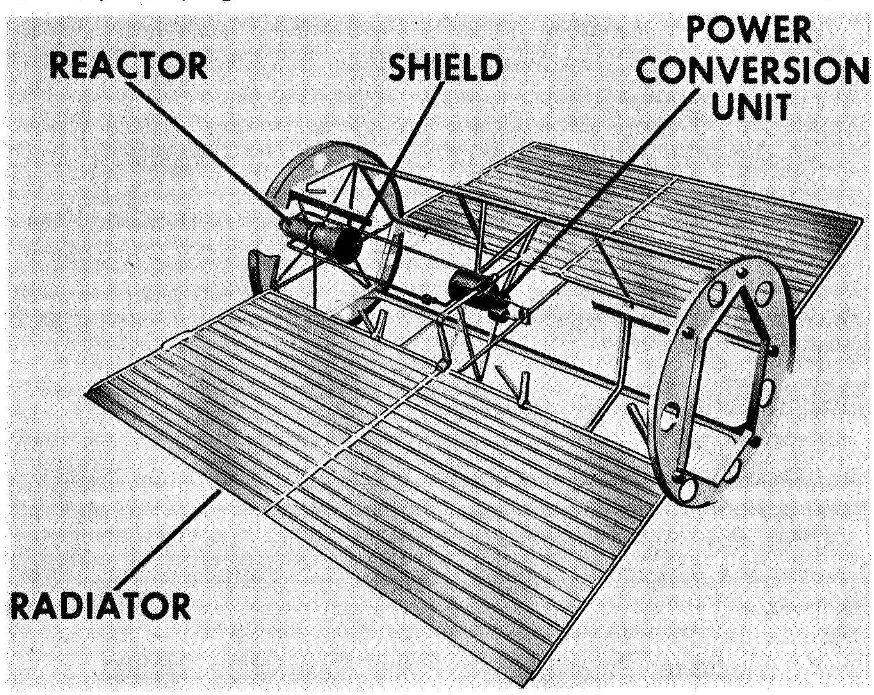
Preparations Made for RIFT Flight-Test Vehicle.—As a first step in selecting a contractor, 31 companies were invited to a proposal briefing in November setting forth the design and development requirements of the upper stage vehicle. The objective of this design and development program, termed RIFT (for *R*eactor *in* *F*light *T*est), is to demonstrate that nuclear rocket flight is technically feasible.

Nuclear Electric Power Generation

The objective of this program is to develop small, lightweight nuclear power sources for satellites, spacecraft, and other special applications. Work was conducted with AEC on the SNAP-8 project (SNAP—*S*ystems for *N*uclear *A*uxiliary *P*ower) which uses heat from the operation of compact reactors being developed by Atomics International.

SNAP–8.—The objective of this project is to develop a nuclear electric generating system to be used for power in orbital tests of experimental electrical propulsion devices and on-board power when spacecraft requirements reach 30-kw. or more, as in TV communications satellites. AEC is responsible for developing the reactor, reactor control, and shielding; NASA is responsible for developing the power conversion equipment into an operational system, integrating it into a suitable flight vehicle, and flight testing the entire system.

Progress was made in fabricating the first SNAP–8 experimental reactor, which was near completion at the end of the report period. The mercury-rated power loop was operated at design temperatures and pressures in December. The loop checkout started September 25. Construction of the ground prototype nuclear test facility at Santa Susana, Calif., began in December.



SNAP-8 electrical generating system.

Electric Propulsion

NASA is sponsoring research and development on three types of electric-propulsion engines—electrostatic (ion), electrothermal (arcjet), and electromagnetic (plasma). Electric power for these engines will be provided by solar or nuclear electric power generation systems, depending upon the power levels required for given missions.

Electrostatic (Ion) Engine

Work progressed on two ion engines being developed for NASA. Each will have 0.002 pounds of thrust.

The Hughes Research Laboratory (Malibu, Calif.) continued developmental work, under NASA contract, on one of these engines—a cesium ion engine model. In September this contractor successfully demonstrated an experimental module of this engine with 0.001 pounds of thrust.

The Lewis Research Center continued developing an ion engine that uses mercury as a propellant to produce its thrust.

Flight tests of these two engines late in 1962 will establish whether ion engines can operate under true space conditions.

Electrothermal (Arc-Jet) Engine

1-Kilowatt Laboratory Model Produced.—Plasmadyne Corp. (Santa Ana, Calif.) continued developing for NASA a 1-kw. arc-jet engine for possible application in controlling the attitude and the stabilization systems of satellites having "stationary" orbits (those synchronous with the rotation of the earth). The contractor completed a laboratory model of the engine.

Work on 30-Kilowatt Model Begins.—Two contractors—the General Electric Co. (Evandale, Ohio) and AVCO–RAD (Wilmington, Mass.)—began work on a laboratory model of a 30-kw. arc-jet engine about the size of a thermos bottle and producing one-half pound of thrust.

Electromagnetic (Plasma) Engines

MHD Techniques for Space Propulsion.—A group of NASA contractors continued experiments on magnetohydrodynamic (MHD) techniques for space propulsion. (For a discussion of MHD and the contractor engaged in exploring its possibilities, see NASA's Fifth Semiannual Report to Congress, Chapter 8, "Propulsion and Power Generation.")

Sunflower Solar Electric Power Generating System

Project Sunflower, under the technical direction of Lewis Research Center, has as its objective the development of a 3-kw. solar-electrical power generating system for spacecraft. A mirror 32 feet in diameter (made up of many petals so that it can be folded during launching) focuses sunlight into a cavity receiver where it boils mercury circulated through tubes in the wall of the receiver. The mercury vapor thus produced is expanded through a turbine which drives an electric generator. Upon leaving the turbine, the mercury is condensed in a radiator and pumped back to the solar-heated boiler to be recycled.

During the report period, work progressed on the 32-foot petalline solar concentrator and on two preprototype boiler heat storage units. Tests of the preprototype 1–A boiler heat storage unit were satisfactorily completed. The preprototype 2–A unit was loaded with lithium hydride and is ready for installation in the system's test booth.

Work Continues on Solar Concentrators

In support of electrical power systems requiring the collection and concentration of solar energy, work continued on the development of rigid, one-piece electroformed nickel concentrators and on deployable, umbrella-type concentrators having an aluminized Mylar membrane over a number of rigid ribs. A 10-foot umbrella concentrator was tested at Langley Research Center, and work continued on the mockup of a 15-foot-diameter umbrella concentrator. At Electro-Optical Systems, Inc. (Pasadena, Calif.), and under the technical direction of Jet Propulsion Laboratory, significant improvements were made in the fabrication techniques and performance obtained in 5-foot-diameter electroformed nickel solar concentrators.

Hydrogen-Oxygen Fuel Cell Development

The hydrogen-oxygen fuel cell system offers a number of inherent advantages for certain space flight applications, for example, high-energy conversion efficiency, minimum of moving parts, no requirement for solar orientation of the spacecraft, and availability of water as a byproduct which can be utilized for equipment cooling or crew consumption on manned spacecraft.

A development program has been initiated directed toward the design, fabrication, and testing of a 250-watt experimental fuel cell power supply system, with the intent of providing the technology for flight application of fuel cells, when required. The development contact is with Pratt and Whitney Aircraft and is under the technical direction of Lewis Research Center.

During the report period, the major components of the experimental fuel cell system were designed and fabricated, and preliminary tests were completed. Electrode performance has met or exceeded expectations, and the complete power plant is being assembled for test.

Space and Aeronautics Research Activities

Research Advances Knowledge

Man's ability to operate a high-altitude hypersonic aircraft effectively under conditions of weightlessness and in spite of acceleration forces that pushed him forward in his cockpit seat or forced him back against it, has been confirmed by the flights of the rocket-propelled X–15.

Equally significant have been the data supplied by this research plane on aerodynamic heating, throttleable rocket engine performance, structures capable of withstanding extremely high temperatures, and on cosmic radiation in the upper atmosphere.

Data furnished by the X–15 flights also demonstrated that a pilot could fly the craft when it reentered the earth's atmosphere—proving conclusively that he is needed at the controls constantly and not merely when an emergency arises. Working throughout a flight he would be a part of the system and ready to take over in the event of a malfunction.

At least 35 additional flights of the X–15 have been scheduled through 1964, at which time another research aircraft, the Dyna-Soar rocket-powered glider, should make its first manned orbital flight.

The Dyna-Soar (X–20) plane (after *dynamic soaring*—flight employing centrifugal force and aerodynamic lift) is being designed to have a significant maneuvering capability and to fly as fast as 24 times the speed of sound.

NASA's scientists, in September, participated in an engineering inspection and evaluation of a mockup of the craft. The Air Force, in December, announced the elimination of previously scheduled suborbital test flights—allowing a cut of 2 years in the Dyna-Soar program and permitting the first launching of the manned glider by a rocket booster in 1965.

In November—heralding a long-awaited refinement in the helicopter—a subcontract was awarded by the General Electric Company to the Ryan Aeronautical Co. (San Diego, Calif.) for the design of a *v*ertical *t*ake*o*ff and *l*anding (VTOL) plane capable of a forward speed of 500 m.p.h. The craft was slated to be flown in May 1963.

Among the noteworthy results of extensive space-oriented research announced during this reporting period are the discovery of ways to dissipate energy released when a space vehicle lands on earth, and the promise of reinforced plastics for storage tanks of liquid-oxygen and liquid-hydrogen.

Research Aircraft

The work that went into building the X–15, studies of new materials and how they functioned as parts of its airframe, and the solution of excessive heating problems of this part airplane and part space vehicle have combined to produce information basic to future spacecraft and aircraft.

Projects planned for this experimental airplane through 1964 include: ultraviolet photographs of the stars, studies of micrometeorites and of infrared engine-exhaust characteristics above 100,000 feet, and the measurement of radiation at this altitude, including investigations of radiation effects on simulated animal and plant tissue.

Another research aircraft—the rocket-launched Dyna-Soar glider—is being developed (in a joint Air Force-NASA program) to soar around the world at an altitude of 100 miles, with its pilot in full control upon reentering the earth's atmosphere at about 15,000 miles an hour. He would be able to shorten or lengthen his range and deviate to either side of his path to reach a selected landing site.

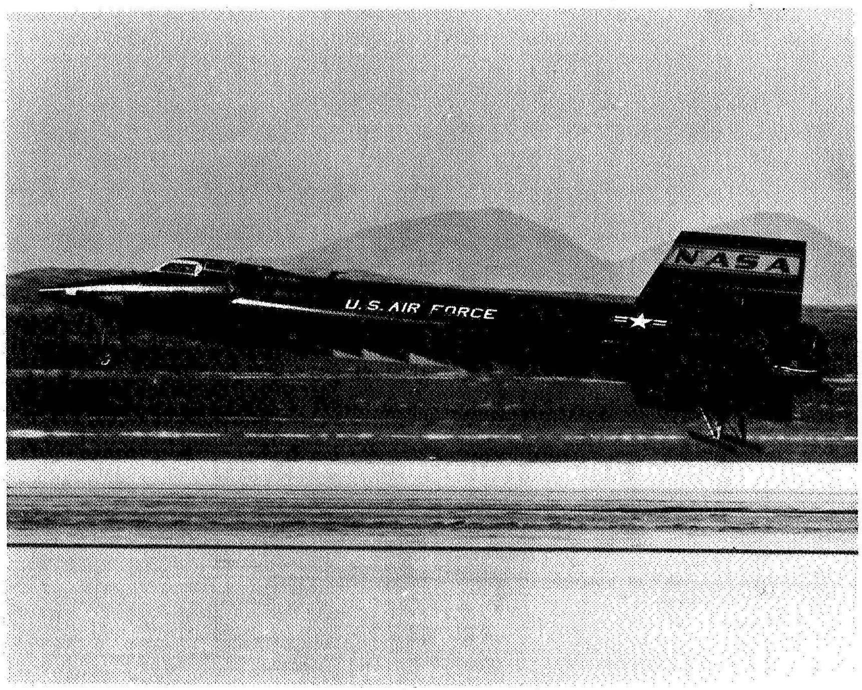
Detailed descriptions of the X–15 and Dyna-Soar were contained in the Fifth Semiannual Report to Congress (Chapter 12, "Special Research Projects"). The following section therefore reviews progress in these two projects for the period July 1–December 31, 1961.

The X–15

Certain classes of space vehicles of the future can benefit by having a man aboard, the USAF-Navy-NASA research program with three North American X–15 aircraft has proved beyond a doubt. In at least 14 of the 44 X–15 flights through November 20, the craft would have been destroyed had it not been for the pilot's skill in correcting system malfunctions and changing determined methods of operation.

This research program has likewise provided vital data on controlled reentry from outside the earth's atmosphere, and on manned control of large rockets during the brief (about 80 seconds) but critical initial powered phase of a spacecraft's flight.

At a conference on the progress of the X–15 project, held at NASA's Flight Research Center, Edwards Air Force Base, Calif., November 20–21, it was concluded that most of the programmed work originally planned is nearly completed—with about 50 percent of the data on aerodynamics, structures, heating, and bioastronautics already



X-15 research airplane landing at Edwards, Calif.

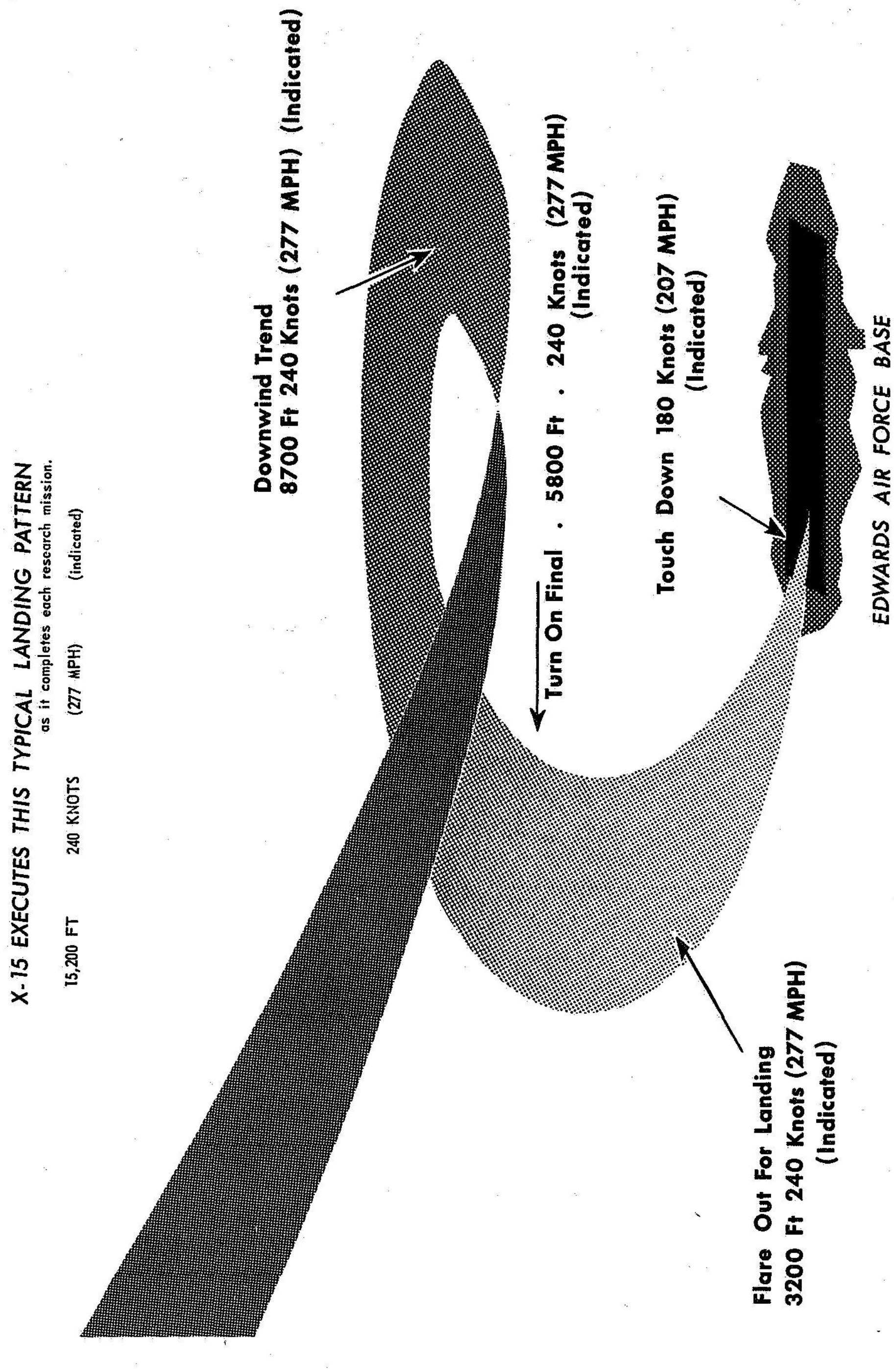
obtained. Further, the pilot's role—kept in proper perspective throughout the project—has paved the way for simpler operational procedures to help insure success in future space programs.

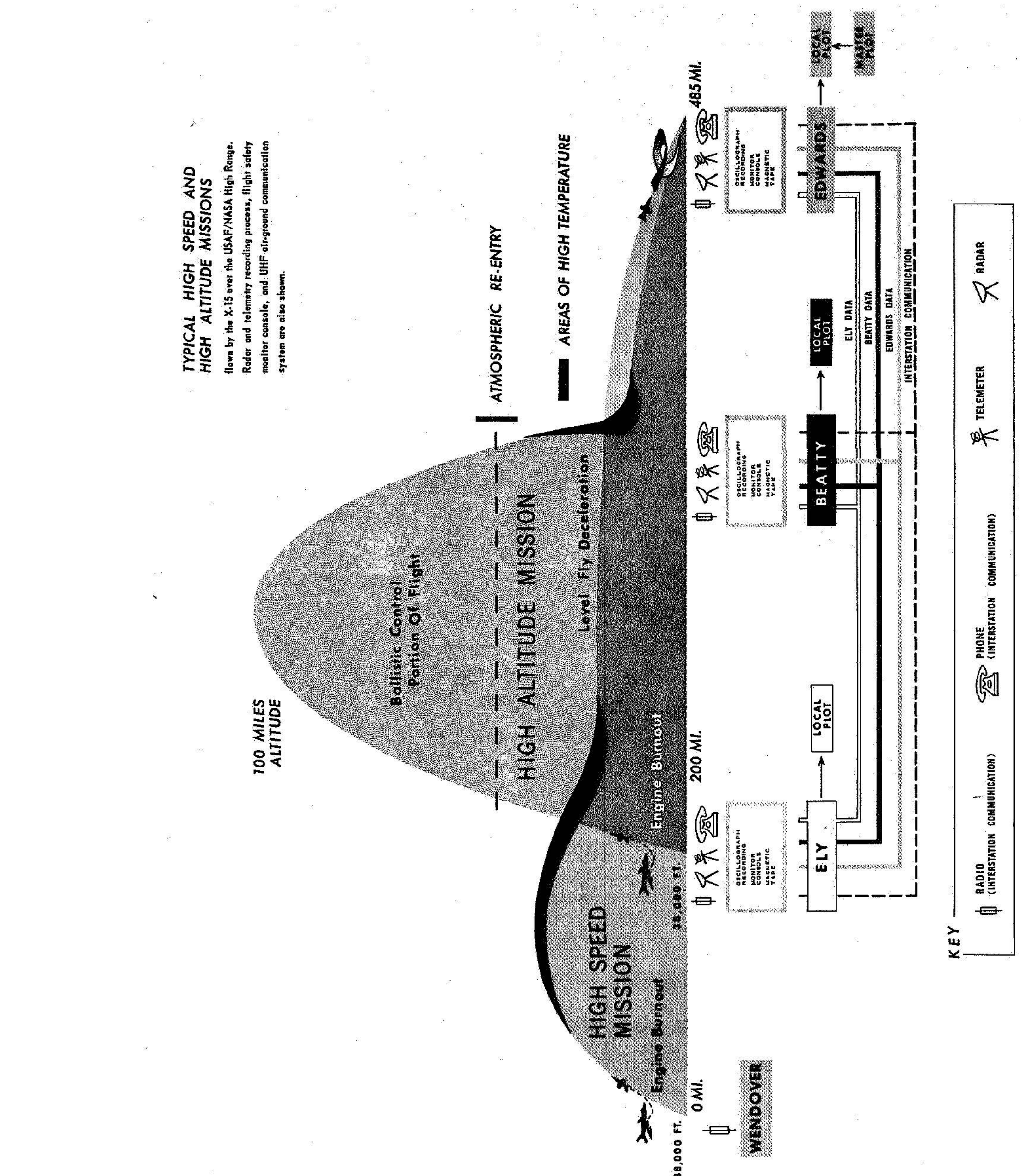
Results from the X-15 experiments continue to have far-reaching benefits, ranging from the supersonic airliner (reported in subsequent paragraphs) through the suborbital and orbital flights of the Mercury astronauts to the Apollo lunar exploration space vehicles.

On November 15—the anniversary of the first flight of the X-15 with its XLR-99 rocket engine—test data indicated that the craft's designed limit in altitude could probably be exceeded by 40 percent. Earlier in the month Maj. Robert White (USAF) flew the plane at a record speed of 4,093 miles per hour.

The extremely high speed and altitude capabilities of this research aircraft should make it increasingly available as a flying laboratory operating between 150,000 and 350,000 feet—heights greater than those obtained by balloons but lower than those for satellites.

Experimenters could capitalize on the ability of the X-15 to provide on-the-spot pilot input in the course of an experiment and the return of the equipment to the ground for evaluation or modifications of the experiment, if required.


X-15 EXECUTES THIS TYPICAL LANDING PATTERN
as it completes each research mission.
15,200 FT 240 KNOTS (277 MPH) (indicated)
Downwind Trend
8700 Ft 240 Knots (277 MPH) (Indicated)
Turn On Final . 5800 Ft . 240 Knots (277 MPH)
(Indicated)
Touch Down 180 Knots (207 MPH)
(Indicated)
EDWARDS AIR FORCE BASE
Flare Out For Landing
3200 Ft 240 Knots (277 MPH)
(Indicated)


TYPICAL HIGH SPEED AND HIGH ALTITUDE MISSIONS
flown by the X-15 over the USAF/NASA High Range. Radar and telemetry recording process, flight safety monitor console, and UHF air-ground communication system are also shown.
100 MILES ALTITUDE
ATMOSPHERIC RE-ENTRY
AREAS OF HIGH TEMPERATURE
Ballistic Control Portion Of Flight
HIGH ALTITUDE MISSION
Level Fly Deceleration
Engine Burnout
HIGH SPEED MISSION
Engine Burnout
38,000 FT.
38,000 FT.
0 MI.
200 MI.
485 MI.
WENDOVER
ELY
BEATTY
EDWARDS
LOCAL PLOT
LOCAL PLOT
LOCAL PLOT
MASTER PLOT
OSCILLOGRAPH RECORDING
MONITOR CONSOLE
MAGNETIC TAPE
ELY DATA
BEATTY DATA
EDWARDS DATA
INTERSTATION COMMUNICATION
KEY
RADIO (INTERSTATION COMMUNICATION)
PHONE (INTERSTATION COMMUNICATION)
TELEMETER
RADAR

Typical high speed and altitude missions, and a typical landing pattern for the craft are shown by the two diagrams on pages 108 and 109.

The Dyna-Soar (X-20) Program

Manned orbital flights of the rocket-propelled Dyna-Soar glider might be advanced by 2 years the Air Force estimated in December, as it announced the elimination of previously scheduled suborbital flights. First ground launch of the glider, being developed in an Air Force program with NASA technical support, has been planned for 1965.

The major revision in the program calls for the use of one liquid-fueled rocket and two solid-fueled rocket engines that could orbit Dyna-Soar at an altitude of about 100 miles. From that height it could then soar back to earth at speeds of 15,000 miles per hour or greater.

Earlier it had been planned to use a modified Titan II rocket as a single launching booster to hurl the vehicle into the lower edge of space. However, this rocket—with a thrust of some 430,000 pounds—was inadequate for orbital flight. For this reason the Air Force terminated its contract with the Martin Marietta Corp. (Denver, Colo.,) to design the Tital II modification required for Dyna-Soar and signed a new contract with the company to provide the solid-fuel rockets for use in conjunction with the main liquid-fueled engine. The Boeing Co. (Seattle, Wash.) remains the prime contractor for the glider vehicle and systems integration.

At first manned models of the Dyna-Soar glider will be dropped from a B–52 in test runs. Immediately thereafter the glider will be launched into unmanned orbital flights from Cape Canaveral, Fla. After circling the globe once or several times it will land at Edwards Air Force Base, Calif. Manned flights later will follow the same profile.

Supersonic Transport (SST)

The concept of the supersonic commercial transport—a craft which would carry at least 120 passengers and cruise at more than 2,000 m.p.h. for distances of 3,500 miles at altitudes above 70,000 feet—is under study by the Department of Defense, NASA, and the Federal Aviation Agency (FAA).

The FAA-suggested timetable for the airliner would require that: (1) Research be completed and contractors selected by 1963, (2) construction be underway in 1964, (3) the first test flight be in 1967, and (4) certification and the beginning of service be set by 1970.

Nearly 200 representatives from the aircraft industry and Government, as well as authorities in aeronautics from England, France, and Canada, met December 5 and 6 in the Departmental Auditorium in Washington, D.C. in formal recognition of the launching of the SST program.

They heard an FAA spokesman outline the formidable systems-wide planning required for the supersonic transport—airports, airways, and traffic control—and emphasize the need to solve the problem of sonic boom. Further, the Agency urged the design of safety into the full system rather than concentration only on the airworthiness of the plane itself.

The extensive research of the SST program in aerodynamics, sonic boom, and related areas was detailed in the Fifth Semiannual Report to Congress (See Chapter 10, "Research Primarily Supporting Aeronautics Activities.")

Subsonic Jet-Transport Research

Full-Scale Slush Tests

A technical conference on the problems of runway slush in jet operations was held by the Federal Aviation Agency and NASA on December 19–20 in Washington, D.C. Featured at the meetings were reports on extensive tests conducted by the two agencies at FAA's National Aviation Facilities Experimental Center in Atlantic City, N.J.

In these tests a heavy, high-speed jet transport was used to measure the effects of runway slush drag during landing and takeoff in a variety of slush depths—created by 2,300 tons of manufactured crushed ice.

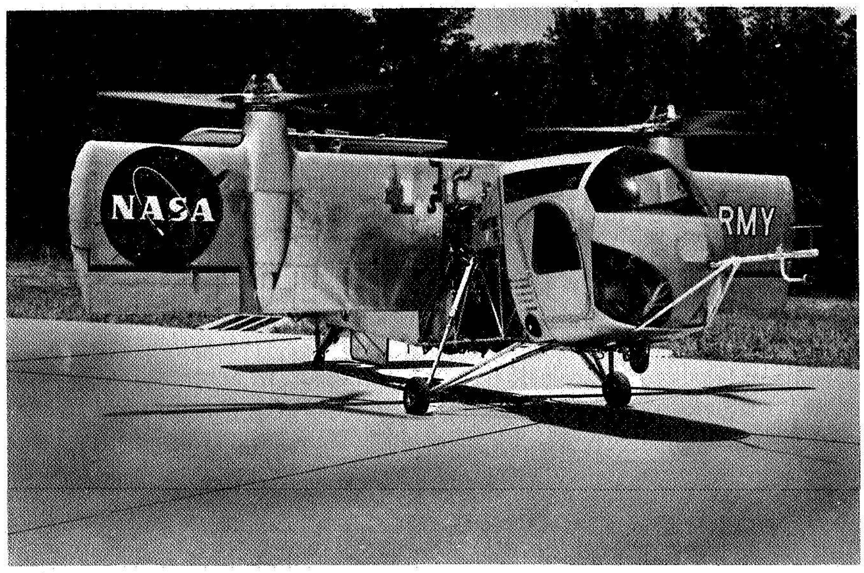
Slush drag on jets was found to be twice as great as previously had been thought. The Federal Aviation Agency subsequently ruled that operations be called off when runway slush reached a depth in excess of half an inch.

VTOL/STOL Aircraft

Over the years extensive research by the National Advisory Committee for Aeronautics and its successor NASA has led to the development phase of V/STOL aircraft.

These *V*ertical *T*ake*o*ff and *L*anding and *S*hort *T*ake*o*ff and *L*anding planes are designed to rise, land, and hover as the helicopter does, yet perform in many ways as a conventional airplane.

Present research into and development of several models of VTOL and STOL craft are briefly reported in the following paragraphs.



Representative tilt-wing configuration of Vertol 76.

Tilt-Wing VTOL Model

The Ames Research Center is conducting large-scale wind tunnel tests of a four-propeller tilt-wing VTOL model plane, with wing stall control devices, built by the Vertol Division of the Boeing Co., Seattle, Wash.

Ryan VTOL Plane

In November the General Electric Co. awarded the Ryan Aeronautical Co. (San Diego, Calif.) a subcontract to design a VTOL aircraft capable of a forward speed of 500 m.p.h.

The development of the jet-powered craft—able to rise vertically and then direct its jet system to power high-speed forward flight—is the primary responsibility of the General Electric Co. under the terms of a $10.5 million Army contract. The plane is slated to be flown in May 1963.

Both the Ryan Co. and GE have had extensive experience in V/STOL research—the latter having just completed more than 160 testing hours of lift fan hardware installed in a full-scale aircraft wind tunnel model at the Ames Research Center.

Variable-Stability V/STOL Craft

The Modified Bell X–14 jet airplane—built by the Bell Helicopter Co. of Fort Worth, Tex.—with variable-stability-and-control features developed and installed by Ames Research Center, has been flight-checked for safety and is being used for research at the Center.

Space Rendezvous

As mentioned in chapter 1, one of the purposes of project Gemini is to provide an early capability to test and develop the rendezvous technique.

The Agency announced on December 7 that it would negotiate with the McDonnell Aircraft Corp. (St. Louis, Mo.)—builder of the Project Mercury capsules—to produce the Gemini capsule in time for initial unmanned tests from Cape Canaveral in 1963 or 1964. Design and performance studies of the craft have been made by North American Aviation, Inc. (Los Angeles, Calif.) and the Martin-Marietta Corp. (Denver, Colo.).

Plans call for the Gemini—boosted into orbit by Titan II—to rendezvous with an Agena stage sent into orbit by an Atlas booster; ground stations would determine when to launch the two-man ship and attempt the meeting in space. Propulsion rockets in the two orbiting craft would bring about their rendezvous.

In its December announcement of the expedited space rendezvous program NASA stressed the obviously touchy problem of bringing together in space two vehicles racing at many times the speed of sound without damaging them. This problem would be coupled with the delicate jobs of refueling operations in the vacuum and weightlessness of the space environment and of hooking up or docking the two craft.

The first unmanned test launchings of the two-man space vehicle would hopefully be from Cape Canaveral in 1963 or 1964. Several manned orbital flights would follow. Rendezvous flights and actual docking missions would be attempted in the final stages of the project.

An estimated $500 million would be required to cover the costs of building about a dozen of these craft, plus the additional rockets and associated equipment.

Other Space-Oriented Research

Landing Impact Dissipation Systems

NASA's scientists studying means of dissipating the substantial energy released when a space vehicle lands on earth summarized their findings at a NASA-Industry Apollo Technical Conference held in Washington on July 18–20.

Three types of landing approaches were studied: (1) Almost vertical with little horizontal velocity, (2) nearly horizontal with moderate vertical velocity, and (3) almost horizontal with little vertical velocity.

Systems investigated included: braking rockets, gas-filled bags, breakable metal tubing, aluminum honeycomb, balsa wood, strain straps, skids, and skid-rocker bottoms. Landings were made on hard surface, on sand, and on water to study the effect of various space vehicle configurations on landing dynamics.

Gas-filled bags, although resulting in a heavier landing gear, were found to be one of the easiest types to package compactly. When a very long-stroke system was required to absorb the landing impact, braking rockets were discovered to be the lightest and most practical method studied.

Investigators concluded that landings could be made on water with little difficulty when there was moderate horizontal velocity, and that landings on rough water or in rough terrain at high horizontal speeds were generally not feasible.

Spacecraft for Mars' Atmosphere

Possible shapes for a space vehicle to fly into the atmosphere of Mars are being tested in the supersonic free-flight wind tunnel at Ames Research Center.

Some tests up to Mach 8 (eight times the speed of sound) have been made in the facility.

Reinforced Plastics Research

Lewis Research Center has begun experimenting with a number of different glass cloth-reinforced plastics for possible use in manufacturing tanks to hold liquid oxygen and liquid hydrogen for boosters and space vehicles.

Preliminary results of these tests indicate that the ultimate strength of the reinforced plastic roughly doubles in value when the temperature is reduced from 75° F. to −320° or −423° F. However, model tanks of this material appear to be much too porous to contain liquids under pressure.

Tanks of this type will probably require a built-in sealant of their inside walls, such as thin bladders of Mylar or coatings of silicone rubber, both of which are effective at room temperature.

Life Science Programs

Man and Space Exploration

In a sense there is no such thing as an unmanned space flight. A number of spacecraft in operation and in the planning stages have no human occupant, but these are designed to gather information and to perform various tasks upon command. Craft of this type, boosted by the Scout and Delta launch vehicles, are being used by NASA to carry the life forms of Project BIOS (*B*iological *I*nvestigations of *O*uter *S*pace) into the lower Van Allen radiation regions to study the effects of the stresses of a laboratory in space.

Man is a vital link in the complete exploration of space. The human factor enters into every facet of the man-in-space Project Mercury—for example, in the design, construction, operation, maintenance, and repair of the capsule.

In the course of a space exploration mission the astronaut observes, makes decisions, monitors, and pilots the craft. This has been demonstrated by the first manned orbital flight in February 1962, as it was to a lesser extent by the second manned trajectory flight of July 1961 (page 117).

Now able to orbit the earth, man is increasingly turning his attention to exploring the moon and the planets, and searching for evidence of life in these areas, as detailed in the description of the life detection systems in this report.

An outstanding feature of man is his ability to adapt to his environment. How he and how simpler organisms are able to adjust to the radiation, the weightlessness, and the other stresses of the space environment are being investigated by bioscientists (see table 3).

This space radiation and weightlessness can markedly alter the weight and power requirements of the launch vehicle, design of the spacecraft, and the planning of a specific mission.

As the contemplated space flight stretches from days into weeks or even months, understanding the effects of this hostile environment on the space explorer and protecting him against these stresses becomes a more complex and urgent problem.

On the other hand to protect outer space from contamination by organisms from the earth, NASA's scientists, collaborating with life scientists from industry and from other Government agencies, are developing procedures for sterilizing space vehicles. These germ-free spacecraft are described in one of the accounts of the major activities of the life science programs of NASA between July 1 and December 31, 1961, that follow.

Experiments in Weightlessness

Pennsylvania State, California, Minnesota and Florida State Universities, under NASA sponsorship, are studying the effects of weightlessness and near weightlessness on various simple biological systems. These studies are in addition to those of Project BIOS (table 3) and investigations at Ames Research Center on how zero g effects sperm motility, fertilization, and cell division.

Pennsylvania State University is studying the effects of zero g on single cells; the University of Minnesota the effects of weightlessness on plant respiration and growth; and the University of California the effects of zero g on various cellular phenomena.

These experiments include studies in photosynthesis, protein microsphere formation, hibernating animals, biological time clocks, growth and embryonic development, and the physical chemistry of biological systems.

Table 3.—Biological Investigations of Outer Space (Project BIOS)

EXPERIMENTS WITH RADIATION	
Effect	Test form
1. Genetic—chromosomal and other mutations	Molds, bacteria, barley seeds, human blood cells, and grasshopper embryos.
2. Death, survival, and reproduction	Molds and bacteria.
3. Seed germination	Barley seeds.
EXPERIMENTS WITH WEIGHTLESSNESS	
1. Size and shape of synthetic protein microspheres	Amino acid mixtures.
2. Fertilization phenomena	Sea urchins.
3. Cell division	Fertilized sea urchin eggs.
4. Growth	Barley and amoebae.

Results of preliminary research by NASA's life scientists suggests that the reproduction of yeast cells and cell division of sea urchin eggs may be affected by gravity.

Radiation Studies

The space probes of Project BIOS are primarily concerned with measuring the intensity and extent of radiation encountered in the Van Allen radiation belts and determining how this radiation might effect living matter. Accordingly, experiments carried aloft by an Argo D–8 booster rocket from the Pacific Missile Range in November were designed to study the effects of such radioactivity on algae genetics, mortality, survival, and mutation; survival and mutations of bacteria; mutations of reproducing human blood cells and grasshopper embryonic nerve cells; and mutation of barley seed germination.

Besides studying the effects of radiation the BIOS shots are concerned with experiments in weightlessness and near weightlessness (table 3).

Second Manned Suborbital Flight

On July 21, the second manned suborbital test flight of Project Mercury with Astronaut Virgil I. Grissom was made successfully from Cape Canaveral, Fla. This NASA spacecraft launching—employing the Redstone rocket as in the first manned suborbital flight of Astronaut Shepard on May 5—further paved the way for the earth orbits of John H. Glenn, Jr., on February 20, 1962.

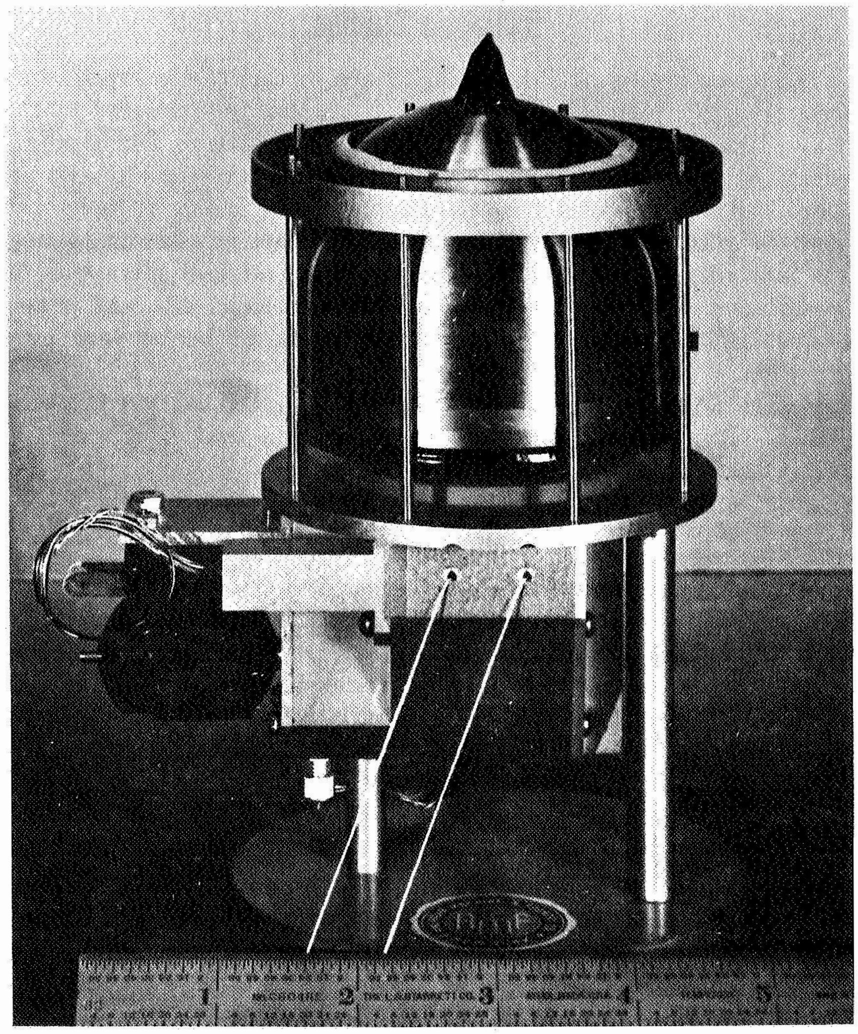
Astronaut Grissom performed his assigned tasks well, maintained voice contact with the ground, and showed no ill effects from flight stresses that included five minutes of weightlessness and a maximum of 11 g's during the capsule's descent.

In the course of its 16-minute flight the space capsule followed approximately the same path as the May trajectory flight—reaching a peak altitude of 118 statute miles and a top speed of 5,280 miles per hour as it traveled 303 miles from the launching pad. (For additional details see Chapter 1, "Manned Space Flight"; "Results of the Second U.S. Manned Suborbital Space Flight, July 21, 1961," Manned Spacecraft Center, National Aeronautics and Space Administration, 58 pp., illus., Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., price 45 cents.)

Life Detection Systems

Radioisotope Biochemical Probe

Resources Research, Inc. (Washington, D.C.) and American Machine and Foundry Co. (Alexandria, Va.) have developed a prototype radioisotope biochemical probe to detect the presence of microbes on



Prototype of a radioisotope biochemical probe designed to detect microbes on Mars.

Mars through the evolution of gases (see photograph above). This device, and similar life detection systems under development (table 4), are planned by NASA to be included in the payload of instrumented spacecraft such as Mariner and Voyager designed for reconnaissance of Mars and Venus.

The radioisotope biochemical probe will carry a carbon (C^{14}) labeled-medium which when acted upon by microorganisms will produce radioactive carbon dioxide. After a Geiger counter measures the extent of the radioactivity this information will be telemetered to earth. Other tagged elements such as sulfur (S^{35}) will be used to provide the widest possible spectrum of identification. A "bacterial smorgasbord" able to nourish a wide variety of organisms will serve as the growth medium.

Organisms will be brought into the culture medium by means of a sticky-impregnated string unwound from a bobbin in a projectile launched by a charge to a distance of 30 to 100 feet. A winch winds the string into the nutritional medium inoculating it. A "hot" medium with as few as 5 cells will detect life in 9 hours. With an inoculum of 1,000 cells, a detemining signal would come in 3 hours.

Table 4.—Several Methods of Life Detection

Method	Description
1. Wolf Trap	Invented by Dr. Wolf Vishniac (University of Rochester, N.Y.) this instrument uses a vacuum to draw samples into culture media, such as beef broth or nutrient broth. When living organisms are trapped, the culture becomes cloudy or undergoes acidity changes.
2. Radioisotope Biochemical probe.	This remote life sampler—about the size of a candy jar and weighing only 1½ pounds—works on a radioisotope principle. A tethered projectile captures the sample and draws it into a growth medium containing sugar labeled with a radioactive isotope of carbon (C^{14}). The organisms may ferment the sugar producing carbon dioxide gas. A radiation counter measures the C^{14} in the gas and telemeters the data to the Earth. A prototype probe has been developed for NASA by Resources Research, Inc. (Washington, D.C.) and American Machine and Foundry Co. (Alexandria, Va.).
3. "J" Band Formation	Aeronutronics (a division of the Ford Motor Co.) has contracted with NASA to design and develop a device that will detect proteins by band formation. In this method cyanin dyes brought into contact with proteins produce intense bluish-black "J" bands in the visible wave lengths of light.

Additional instruments being designed and developed for the remote detection of extraterrestrial life include the infrared spectroscope described below under "Infrared Studies of the Planets", and the high-resolution vidicon (TV) microscope mentioned in the *Fifth Semiannual Report to the Congress—October 1, 1960–June 30, 1961*.

This device—developed, tested, and brought to basic engineering design in the past 11 months—is small, sensitive, and reliable, but rugged enough to be used in a Mariner B flight or given a lunar field test in a Surveyor mission.

Infrared Studies of the Planets

When it isn't feasible to land on a neighboring planet and meteorites are not available for analyses, scientists may use infrared spectroscopes carried in high altitude balloons or mounted on planetary orbiters to detect life-related compounds and to study the composition of the planet's atmosphere for analysis of its constituents.

NASA plans that a major instrument on Mariner spacecraft should be such a spectroscope that could search the mysterious cloudy atmosphere of Venus for the presence of life-sustaining oxygen and water vapor. The Mariner's space probes could also make infrared studies of Mars to determine if that planet contained organic compounds.

The University of California is designing an infrared spectroscope that can be attached to a 36-inch telescope and carried by a balloon above 80,000 feet to examine Martian surfaces for evidence of organic compounds. Capable of being automatically trained and focused, the telescope is a modification of one designed for the Navy, the National Science Foundation, and NASA by Dr. Martin Schwarzschild of Princeton University.

Instrumentation of this type should make possible investigations of a variety of organic molecules of Jupiter as well as Mars and Venus, and the detection of water vapor, methane, ammonia, and carbon dioxide in planetary atmospheres.

Analyzing Meteorites for Traces of Life

National interest has recently been aroused by reports of the identification of carbon-hydrogen compounds, paraffin substances, and living microorganisms in meteorites by scientists at New York, California, and Fordham Universities, at the National Institutes of Health, and by investigators of the Esso Research and Engineering Corp. (Linden, N.J.).

These reports, coupled with similar research results from Russian studies in 1953, have caused considerable controversy over the possibility that the fragments analyzed could have been contaminated by contact with the earth and therefore not free enough of earth's compounds and microorganisms for a valid analysis of possible evidence of extraterrestrial life.

In the past sky and landscape watchers in forest fire lookout towers, in airport control towers, and even airplane pilots have spotted meteorite falls. However, the meteorites subsequently found by this "watch-and-find" method have been rare, pointing up the need for a systematic approach to the problem such as the camera tracking system proposed by the Astrophysical Observatory of the Smithsonian Institution.

Microbes in the Upper Atmosphere

Dr. Sanford S. Elberg, a life scientist at the University of California, and life scientists at General Mills, Inc. (Minneapolis, Minn.), have contracted with NASA to study microorganisms in the upper atmosphere of the earth.

The distribution of microbes in this area revealed by these studies may shed some light on the means by which living spores are transferred from planet to planet.

Origin of Lifelike Elements

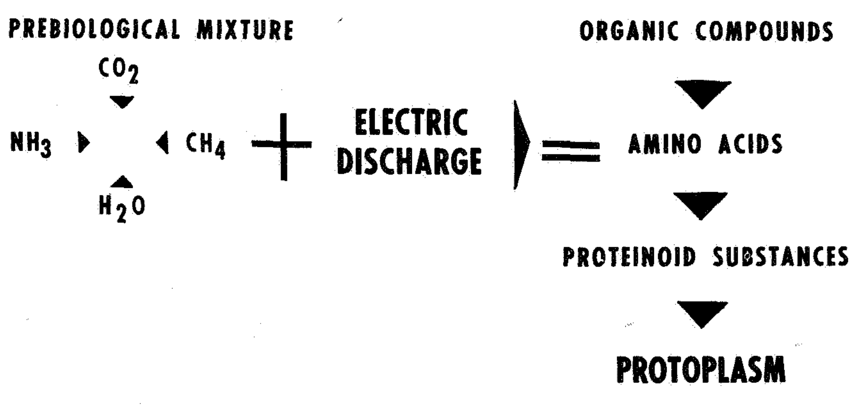
Living matter is made up of organic compounds called amino acids—some hundreds or even thousands of amino acid molecules combine to form each protein molecule. About 25 different amino acids are known to be constituents of proteins, and most of these acids have been found in all organisms studied.

Proteins are in turn very complex organic compounds present in every type of life and make up a considerable proportion of the dry weight of the organism. They are synthesized by living matter through processes as yet not fully understood. However, chlorophyll-containing plants and a few bacteria can manufacture organic materials directly from water, carbon dioxide, nitrates, and other salts using sunlight as the source of energy.

Dr. Sidney W. Fox of Florida State University, supported by a NASA grant to investigate the "chemical matrices of life," has succeeded in synthesizing protein-like microspheres from amino acids. The latter can be synthesized from substances under conditions similar to those that existed at the time that the earliest forms of life originated. (See accompanying diagram.)

The amount of gravity operating during the synthesis period determines the size of these microspheres. One g, for example, can produce microspheres the size of bacteria—supernormal gravity yields larger particles.

During 1962 Dr. Fox will explore the effects on his microspheres of 20 to 24 minutes of minus g in the course of a short trajectory flight. (In November 1961 a similar experiment was included as part of a NASA BIOS payload launched unsuccessfully by an Argo D–8 booster rocket from the Pacific Missile Range. The vehicle veered sharply off course 57 seconds after launch and the payload was lost.)



Electric discharge combines early earth or planetary gases producing compounds basic to living matter.

Although like the November attempt the 1962 flight should supply only 20 to 25 minutes of near weightlessness, this brief interval could provide scientists with vital information in reconstructing a major step in biochemical evolution that may have taken place over 4 billion years ago. Longer periods of weightlessness will be provided in the future for similar observations.

In related research Dr. Scott Blois at Stanford University—also assisted by a NASA grant—is searching into "molecular evolution." He hopes to produce the complicated organic catalytic chemicals found in and vital to life processes by introducing iron and other metals into a primitive atmosphere mixture.

Space Simulation Studies

Whether microorganisms can survive the heat, cold, ionizing radiation, ultraviolet energy—and particularly the very high vacuum of space—may influence NASA's preparations for future planet probes and answer some questions about extraterrestrial life. (See diagram on opposite page.)

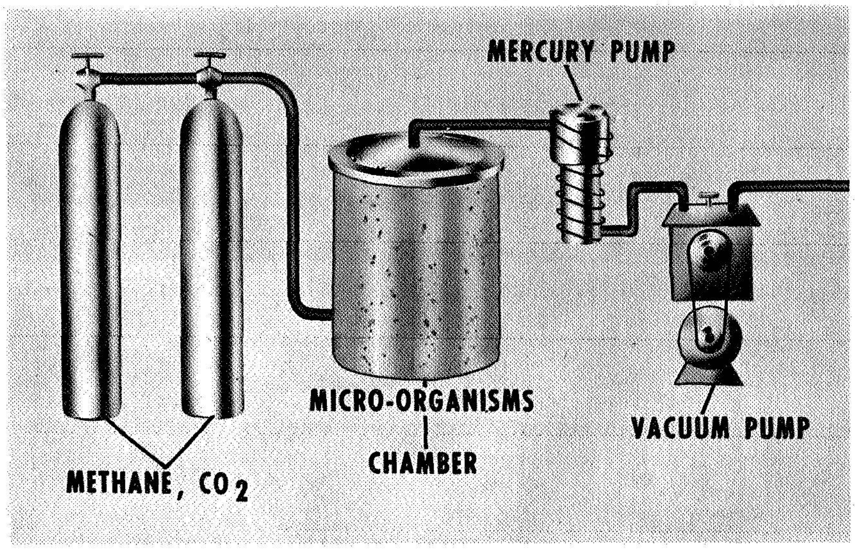
The incredibly tough spores of several bacteria (B. subtilis and Aspergillus niger) have been able to withstand for 5 days a hard vacuum typical of space—demonstrating that the space vacuum can't be relied upon to sterilize vehicles destined for lunar landings.

Research into simulating the atmosphere of Mars is being carried on by the Armour Research Foundation (Chicago, Ill.) under a NASA contract to investigate life on other planets. Recently the Foundation reported that several species of earth's bacteria could conceivably exist on Mars, and selected several algae isolated from lichens growing in the Antarctic in additional tests of the survival of microorganisms in the Martian atmosphere.

During this report period similar research at the University of California has resulted in isolating from the salt flats of San Francisco Bay microbes that can survive and reproduce in the absence of moisture. These bacteria—able to tolerate high salt concentrations in solution—could possibly exist on Mars where there is very little liquid water.

Germ-Free Spacecraft

Scientists are concerned that other planets may become contaminated by life forms from earth. Terrestrial organisms could not only destroy outer-space ones, but confuse scientific investigators by making it almost impossible for them to identify a particular life form as originating beyond the earth or of having been introduced by a space vehicle.



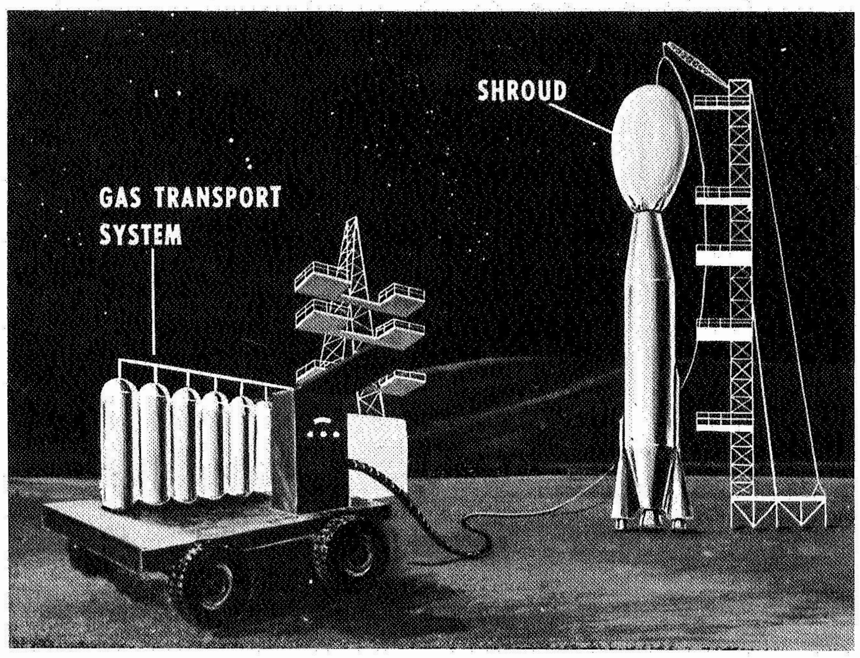
Microorganisms are exposed to heat, cold, and very high vacuum in space-simulated conditions on earth.

Since there is this urgent need for germ-free spacecraft, the U.S. Army at Fort Detrick (Frederick, Md.) has developed for NASA procedures to decontaminate Ranger A–3—the first lunar impact vehicle. This sterilization technique—consisting of applications of liquid and gaseous sterilants—is minimal and was devised to serve as the basis for perfecting more effective decontamination procedures.

The figure on pp. 124 shows tanks of ethylene oxide—a colorless gas used to fumigate foodstuffs and textiles—being wheeled up to sterilize a space probe. (A shroud confines the gas during the sterilization process.)

The Hughes Aircraft Co. (Culver City, Calif.), prime contractor for the instrumented lunar spacecraft Surveyor, has specified decontamination requirements for subcontractors of the craft's components and subcomponents. The entire retrorocket system of the vehicle has been designed to be sterilized by dry heat.

The Hughes Company is expected to complete a decontamination system for the entire spacecraft well in advance of the design freeze scheduled for the spring of 1962.



Sterilizing a space probe with ethylene oxide gas.

Construction of Facilities

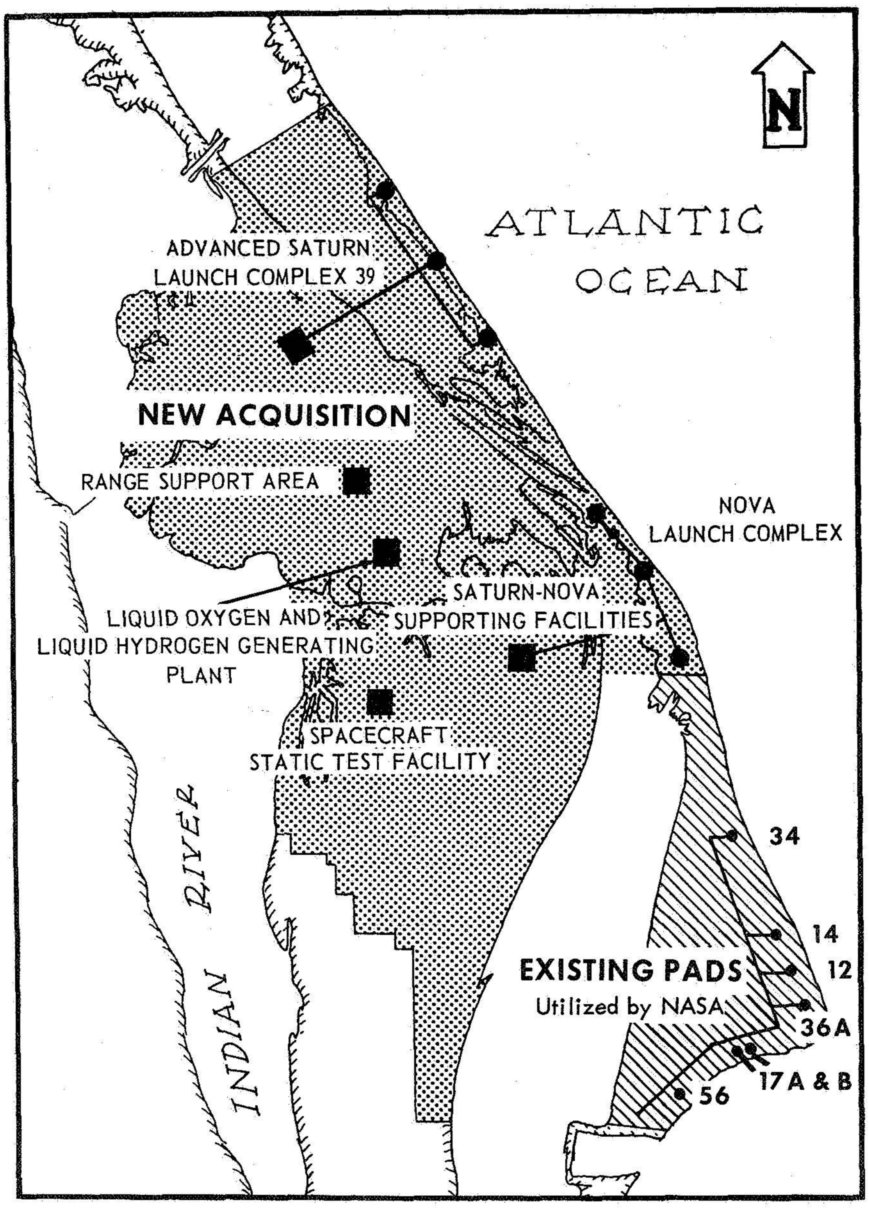
Building Progress Substantial

NASA has issued a 51-page illustrated booklet[1] describing briefly the Agency's field establishment. The mission, location, land, plant value, as well as the number of employees, operating cost, and construction program for fiscal years 1962 and 1963 are given for each installation.

Representative of the substantial progress made in building facilities for these installations during July 1 through December 31, 1961 are the items reported in the following table:

Facility	Progress
ATLANTIC MISSILE RANGE, CAPE CANAVERAL, FLA.	
Second Saturn C-1 launch complex (No. 37)—two launch pads, blockhouse, umbilical and service tower, associated fuel and test facilities, and instrumentation.	Contract awarded Blout Brothers Construction Co. (Montgomery, Ala.) on September 13 to build facility by December 1962. Annual launchings of C-1 type Saturns will more than double from this new complex.
Saturn C-3 and Nova launch complexes.	80,000 acres north of the Range are being acquired for $60 million (estimate) as launch sites of multi-million-pound-thrust boosters for manned lunar landings.
MANNED SPACECRAFT CENTER, HOUSTON, TEX.	
Manned space flight center to be situated on 1,000 acres of land made available to U.S. Government by Rice University. Will be used to design, develop, evaluate, and test space vehicles for Project Apollo and to train crews to fly these missions.	In September NASA announced selection of Houston site for $60-million laboratory. Fiscal year 1962 funds were provided for developing site and for building flight project facility, equipment evaluation laboratory, flight operations facility, and environmental testing laboratory.
JET PROPULSION LABORATORY, PASADENA, CALIF.	
Space simulator to test the effects of solar radiation and high vacuum on full-scale Ranger and Mariner class spacecraft.	Construction underway in July on this facility—first of its type in the United States.
Very large deep space tracking antenna to enable the Laboratory's Deep Space Instrumentation Facility at Goldstone, Calif., to maintain radio contact with spacecraft.	Blaw Knox Co. (Pittsburgh, Pa.) selected in August to complete a feasibility and design study by July 1962. Schedule calls for antenna to be operating at Goldstone by January 1, 1965.

[1] Copies are available without charge from: Office of Educational Programs and Services, National Aeronautics and Space Administration, Washington 25, D.C.



56 MERCURY – REDSTONE
17A & 17B DELTA
36A CENTAUR
12 AGENA
14 MERCURY
34 SATURN

NASA Atlantic Missile Range.

GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.	
Facility	**Progress**
Site for Mississippi Test Facility—about 35 miles from NASA's Michoud Plant in New Orleans, La.—announced on October 25.	Static test firings for Saturn C-1, Advanced Saturn, and Nova in the manned lunar landing program will be possible on this 13,500-acre facility. Rights to an additional 128,000-acre buffer zone are also being acquired.
LEWIS RESEARCH CENTER, CLEVELAND, OHIO	
Plum Brook Reactor Facility (Sandusky, Ohio)—60,000-kw., tank-type reactor for research into nuclear propulsion problems, e.g., radiation, fluid flow, heating, and shielding. Investigations of reactors for auxiliary electric power generation in space (SNAP) are also undertaken here.	Equipment for use in reactor experiments designed and built. Reactor has been operating at 100 kw.; scheduled to operate at 60,000 kw. in May 1962.
AMES RESEARCH CENTER, MOFFETT FIELD, CALIF.	
Wind tunnel to study reentry of spacecraft into earth's atmosphere at speeds of Mach 7.5, 10, and 15.	Facility began operating in August.
LANGLEY RESEARCH CENTER, LANGLEY AIR FORCE BASE, VA.	
High temperature wind tunnel to simulate aerodynamic heating and loading of hypersonic aircraft.	In August contract awarded Marquardt Corp. (Van Nuys, Calif.) to increase tunnel's testing temperature from 600° F. to 2,000° F.

International Programs

Worldwide Cooperation

During this report period NASA, as charged by the Space Act of 1958, continued to devote its space activities "to peaceful purposes for the benefit of all mankind." By December 1961, 50 nations were taking part in NASA programs or being helped by NASA to launch their own space programs.

Tracking Network Negotiations

The Republic of South Africa completed the Deep Space Instrumentation Facility, one of many foreign tracking stations to be used by NASA. The station—at Hartebeesthoek, near Johannesburg—was dedicated on September 8 by South Africa's Council for Scientific and Industrial Research.

A total of 551 foreign nationals visited NASA during the report period, among them officials connected with space activities in Argentina, Australia, Canada, France, India, Italy, Japan, Norway, Pakistan, Sweden, Switzerland, and the United Kingdom. Officials of the European Preparatory Commission for Space Research also visited the Agency.

Postdoctoral Research Grants

By the end of the report period, scientists from 13 countries had begun or continued research at the Goddard Institute of Space Studies under postdoctoral grants administered by the National Academy of Sciences for NASA.

International Fellowship Program

In September, seven fellows from five countries enrolled at six U.S. universities to study the space sciences under NASA International Fellowships. With them began a program eventually to accommodate up to 100 foreign students annually on a shared-cost basis at 18 or more American universities.

Foreign Training at NASA Centers

Forty-eight tracking station personnel from 13 countries had received training in space research at Goddard Space Flight Center by the end of the period.

International Astronautical Federation Congress

The Agency held a formal reception for delegates to the International Astronautical Federation Congress, meeting in Washington October 2 to 8, and arranged for those interested to visit Goddard Space Flight Center.

NASA Personnel Visit Foreign Countries

NASA's activities required 295 of its personnel to visit foreign countries during the period.

Cooperative Projects

TIROS III Meteorological Satellite

The launching of the TIROS III meteorological satellite on July 12 resulted in a program of international cooperation—ground observations conducted by 29 countries when the satellite was over their territories, and the participation by 39 representatives of 27 nations in the International Meteorological Satellite Workshop. Furthermore, cloud analyses and storm warnings based on TIROS III data were widely disseminated to foreign countries.

Ground Observations.—Twenty-nine foreign countries participated in the TIROS III experiment for 9 weeks beginning August 8. These weather services conducted special ground-based observations synchronized with satellite photography.

International Meteorological Satellite Workshop.—The International Meteorological Satellite Workshop was held from November 13 through November 22 in Washington. The 39 participants represented 27 foreign weather services, all members of the World Meteorological Organization.

The workshop dealt principally with methods of processing and interpreting data obtained by TIROS satellites. The training it offered foreign meteorologists will aid them in preparing weather analyses from TIROS cloud pictures and those to be transmitted by Nimbus and other future U.S. weather satellites.

Communications Satellites

Foreign Countries Aid Rebound and Relay Projects.—The West German Post Office and the Brazilian Department of Posts and Telegraphic Communications agreed to provide ground terminals to be used with experimental communications satellite projects (described in Chapter 3, "Satellite Applications"). The British General Post Office and the French Center for Telecommunications Studies continued construction of ground stations for these projects.

Telespazio, a new Italian communications organization, negotiated an agreement (requiring Italian Government approval) with NASA to receive telecommunications signals from Relay and Telstar satellites.

Other foreign countries have expressed interest in providing ground terminals for the communications satellite program.

Australia

The United States and Australia successfully carried out a sounding rocket survey of ultraviolet radiation in the Southern Hemisphere skies. In these studies, four British-made Skylark rockets were launced from Woomera, Australia. United States scientists processed and anlyzed the ultraviolet data obtained by these rockets for comparison with data derived from similar Northern Hemisphere studies.

Canada

Rocket Launchings.—In November Wallops Station launched Black Brant sounding rockets in developmental tests conducted for the Canadian Defense Research Board. The Fort Churchill launching range in Manitoba, Canada, was not available.

Alouette Satellite.—NASA continued working with the Canadians in preparation for the launching in 1962 of the Canadian-developed Alouette topside sounder satellite, which will be used to study the structure of the ionosphere. NASA plans to furnish the Thor-Agena launching vehicle.

India

NASA-supplied telemetry equipment was installed in the Physical Research Laboratory, Ahmedabad, India, for operation by Indian technicians. This equipment will collect gamma radiation data from Explorer XI.

Italy

NASA continued to cooperate with the Italian National Space Committee in tests with sounding rockets for upper atmosphere research. Coordinated sodium-vapor firings from Sardinia and Wallops Island in September were highly successful.

Japan

NASA and the Japanese Radio Research Laboratory arranged for joint rocket research into the composition of the ionosphere. Wallops Station prepared to launch a Japanese resonance probe and a Goddard Space Flight Center Langmuir probe combined into a single payload on a Nike-Cajun rocket.

656299 O—62——10

Pakistan

NASA and the Pakistan Upper Atmosphere and Space Research Committee agreed to conduct a joint upper-atmosphere sounding rocket program in 1962. Under this program, Pakistanis are being trained at the Goddard Space Flight Center and at Wallops Station and are studying at American universities. NASA is to supply sounding rockets, furnish a launcher on loan, and provide technical assistance for sodium-vapor experiments in Pakistan. Pakistan will supply the sodium-vapor payloads, provide the necessary ground instrumentation, conduct the firings, and reduce and analyze the scientific data acquired.

Sweden

NASA trained Swedish technical personnel at Wallops Station and supplied five rockets in support of the Swedish Space Committee Program to conduct studies of noctilucent clouds in the upper atmosphere. In conducting these studies, the Swedes launched a partially successful Arcas sounding rocket from Jokkmokk, northern Sweden, in August.

United Kingdom

The S–51 satellite, a joint effort of the United Kingdom and the United States, neared completion. (It was launched April 26, 1962, from Cape Canaveral and named Ariel.) A NASA-supplied Delta rocket will launch the satellite, which is to collect data from the ionosphere.

Preliminary plans were developed for a second similar British-United States satellite. The joint working group coordinating the scientific experiments for this satellite held two meetings at Goddard Space Flight Center.

European Space Research Organization

NASA is assisting the European Preparatory Commission for Space Research in studies to develop the organization and research facilities for the forthcoming European Space Research Organization.

The United Nations

In December, NASA's Office of International Programs assisted the Department of State and the U.S. Delegation to the United Nations in formulating a U.N. policy on outer space. This office had previously aided in drafting the U.S. proposals for cooperation in space, presented at the United Nations Space Committee's first meeting, November 2. The Director of the Office of International Programs assisted the U.S. delegation during the discussion of these proposals by the U.N. General Assembly's Political Committee.

International Quiet Sun Year (IQSY), 1964–65

Plans were made for the important part NASA will play in a worldwide solar study projected by the International Council of Scientific Unions. NASA expects to have solar, astronomical, and geophysical observatories in orbit during the IQSY and plans to make solar data collected by these satellites available to all scientific organizations conducting IQSY studies.

Organizational Development

Major NASA Reorganization Effected

Late in September, NASA completed plans for a reorganization to carry out with maximum effectiveness the accelerated and expanded space program that the President and Congress have set for the Nation. The organizational changes, which went into effect on November 1, unify principal elements of major programs to improve program coordination and promote prompt decisions. The new organization also increases the voice of field center directors in establishing policy and making decisions and enables NASA general management to exercise greater control over field programs.

The organization is set up essentially along three levels of responsibility—policy, planning, and operations. The NASA general management, represented by the Administrator, Deputy Administrator, Associate Administrator, and Deputy Associate Administrator, share in making broad policy and major decisions, and exercising general direction of the Agency. The technical and administrative program offices of Headquarters are responsible for the planning and direction of specific programs, projects, and administrative activities. These projects and activities are generally assigned to field centers for execution.

In the new organization, directors of field centers report to the Associate Administrator rather than to particular technical program offices. Field center personnel on specific research, development, and administrative assignments are under functional direction of the appropriate technical program or administrative office in NASA Headquarters.

Program Offices Revamped

The reorganization created four new program offices corresponding to the major areas toward which NASA energies are directed. The program offices establish technical guidelines, budget and program funds, schedule projects, and evaluate progress. They are fully responsible for accomplishment of their programs and can draw on NASA as well as industrial, educational, and other Governmental resources. The responsibilities of the new program offices are briefly touched upon below. Their predecessors, the Offices of Space Flight

Programs, Launch Vehicle Programs, Life Science Programs, and Advanced Research Programs, were abolished.

Office of Manned Space Flight.—Largest of the new offices is the Office of Manned Space Flight, organized to carry out the vital program leading to eventual landing of men on the moon and returning them safely to earth. This office is responsible for development of both spacecraft (Mercury, Gemini, and Apollo) and launch vehicles (Saturn C–1, Advanced Saturn, and Nova) to accomplish its goals as well as for direction of supporting work in aerospace medicine, propulsion, flight missions, and systems engineering and evaluation. On December 31, D. Brainerd Holmes, Director of Manned Space Flight, announced formation of a Management Council of top NASA scientists and engineers to speed work on the lunar landing program including projects leading to that goal. Additional information about the council is presented later in this chapter.

Office of Space Sciences.—The first U.S. craft to land on the moon and on earth's neighboring planets will be unmanned instrumented probes developed under supervision of the Office of Space Sciences. This office is responsible for carrying out a program for investigation of space by means of unmanned satellites, sounding rockets, and probes. Among its projects are the Orbiting Astronomical Observatory to peer deep into the universe from above the obscuring effects of earth's atmosphere, the Orbiting Geophysical Observatory for intensive study of space near earth, Ranger and Surveyor for landing on the moon, and Mariner for launch to the vicinities of Mars and Venus. The office is also responsible for development of launch vehicles for use in its program, such as Scout and Atlas-Centaur. The Office of Space Sciences is also looking into the possibility of life elsewhere than on earth. Moreover, it coordinates research performed for NASA by universities, colleges, and other nonprofit organizations.

Office of Applications.—Development of satellite systems for improving weather forecasts and augmenting world telecommunication channels is among the responsibilities of the Office of Applications. Typical of its programs are the familiar TIROS weather satellite and the Echo communication satellite. The office is also responsible for identifying other spacecraft applications and disseminating information on advances in space technology which appear promising for industrial and commercial usage. In addition to advanced programs in communication satellites (Rebound, Relay, and Syncom) and weather satellites (Nimbus and Aeros), the Office is considering development of a civilian navigation satellite system for use by ships and aircraft of all nations. The system would be based upon the technology of the Navy's Transit satellite program.

Office of Advanced Research and Technology.—Organized around the former Office of Advanced Research Programs, the Office of Advanced Research and Technology coordinates the mission-oriented research and development of other program offices and plans and directs projects not specifically related to the mission of a single program office. Through the Office of Advanced Research Programs, NASA is working with the Atomic Energy Commission on projects to employ nuclear energy as durable sources of electric power for operating equipment on and propelling spacecraft. Other typical research projects are advanced life support systems for manned spacecraft, supersonic air transports, vertical and short takeoff and landing aircraft, the X–15 research airplane, plotting of trajectories from earth to moon and for the safe return trip, and employment of extremely hot electrified gases for propelling upper stages of spacecraft.

Office of Tracking and Data Acquisition.—An additional office reporting to the Associate Administrator under the new organization is the Office of Tracking and Data Acquisition, formerly part of the Office of Space Flight Programs. The office is responsible for managing worldwide ground instrumentation networks set up to monitor, command, and gather information from spacecraft and for developing advanced systems to use with future complex satellites and probes, both manned and unmanned.

Other Headquarters Changes

Several changes were made at the Administrator-Deputy Administrator level:

. . . The position of Deputy Associate Administrator was established to assist in day-to-day management of the NASA field centers.

. . . The position of Assistant Administrator for Public Affairs was established to manage and coordinate public and technical information, and educational programs and services.

. . . The Office of Executive Assistant to the Administrator was established to coordinate staff work in the Administrator's office.

. . . The Office of Congressional Relations was redesignated the Office of Legislative Affairs.

Manned Spacecraft Center Established

NASA redesignated the Space Task Group (Hampton, Va.) as the Manned Spacecraft Center and selected a thousand-acre site near Houston, Tex., as the center's future home. Architectural and engineering work on the center's facilities was inaugurated, and personnel began to relocate from Hampton to temporary quarters adjacent to the new site. The Manned Spacecraft Center has been assigned responsibilities for designing, constructing, and testing craft for manned space flight, for training astronauts, and for supporting manned space flight operations. The Center is engaged in the Mercury manned orbital flight program, the Gemini program to perfect techniques for joining craft in orbit, and the Apollo program for eventually landing men on the moon and returning them safely to earth.

Office for the United Nations Conference Inactivated

NASA's Office for the United Nations Conference was disbanded as of September 30. Subsequently, the Office of International Programs assumed responsibility for NASA's continuing interest in an International Conference on the Peaceful Uses of Outer Space.

Such a conference had been called for by a resolution of the United Nations General Assembly on December 12, 1959. The United Nations Committee on the Peaceful Uses of Outer Space has not, however, met to call the conference within the time period specified in the resolution.

Michoud Plant to Assemble Large Launch Vehicles

On September 7, NASA selected the idle Government-owned Michoud Ordnance Plant near New Orleans, La., for fabricating stages for Saturn C–1, Advanced Saturn, and Nova launch vehicles. Industrial contractors will assemble the massive stages at the plant under technical direction of the Marshall Space Flight Center (Huntsville, Ala.). The plant will also produce the Reactor-in-Flight-Test (RIFT) vehicle to be launched as part of the testing program for nuclear-powered upper stages. The 1.8-million square feet of inactive manufacturing space in Michoud are expected to become after conversion the Nation's largest vehicle-assembly area.

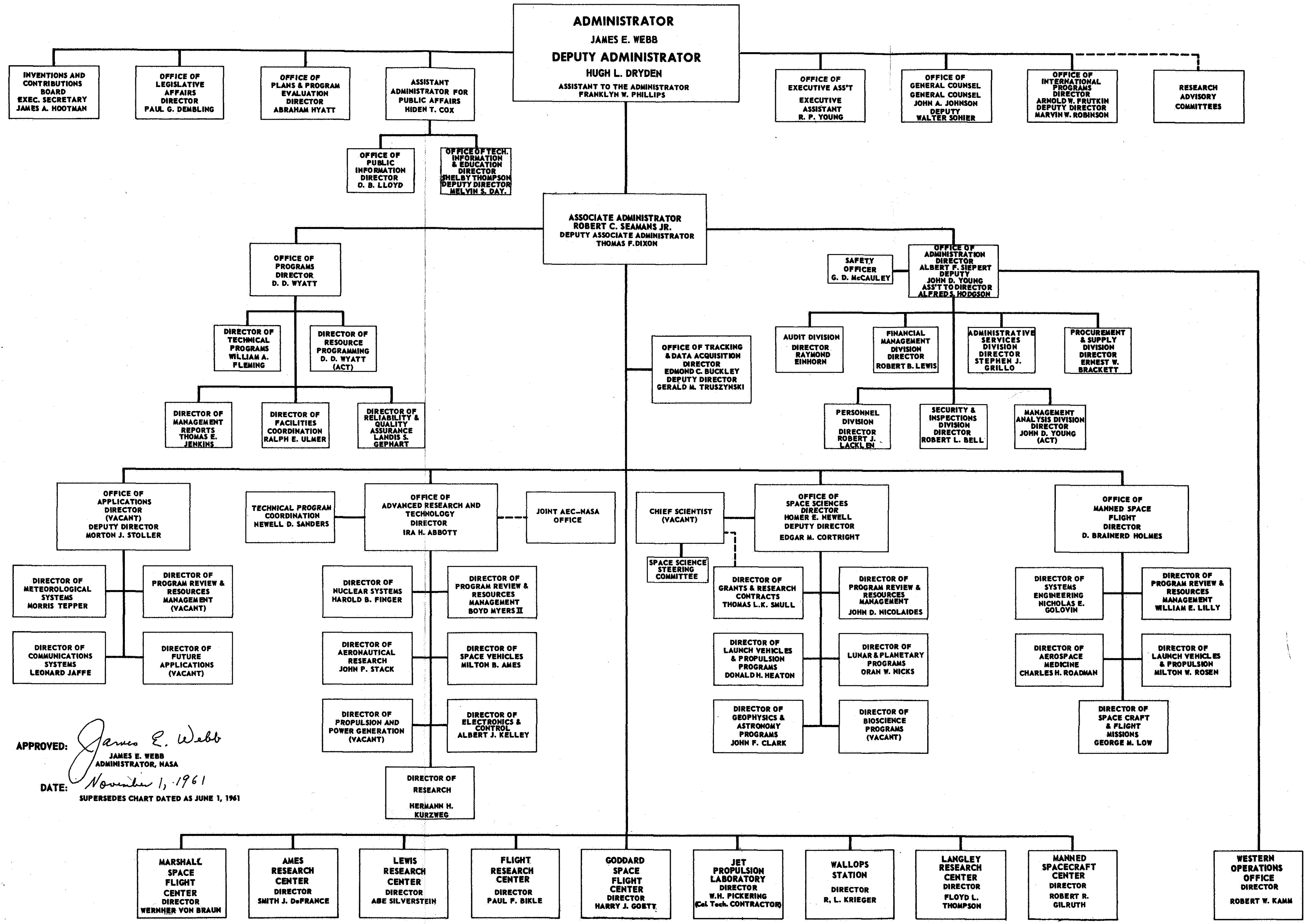
Site Chosen to Ground Test Large Launch Vehicle Stages

On October 25, NASA announced it would acquire 13,500 acres along the Pearl River in southwest Mississippi to establish the Mississippi Test Facility. NASA plans to construct test stands here for ground firing of the large lower stages of Saturn C–1, Advanced Saturn, and Nova launch vehicles. In addition, NASA is acquiring easement rights to 128,500 adjacent acres located in both Louisiana and Mississippi. Residents will be required to move from this area which will serve as a buffer to protect dwellings from shockwaves of rocket tests. Marshall Space Flight Center manages the facility.

Manned Space Flight Complex Takes Shape

NASA's four facilities in Houston, New Orleans, Huntsville, and southwest Mississippi together with the launch complexes at Cape

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



APPROVED: James E. Webb
JAMES E. WEBB
ADMINISTRATOR, NASA

DATE: November 1, 1961

SUPERSEDES CHART DATED AS JUNE 1, 1961

656299 O - 62 (Face p. 139)

Canaveral constitute an integrated organization to prepare for man's conquest of space. Here, astronauts will be trained, and spacecraft and launch vehicles leading eventually to manned landings on the moon will be built, tested, and launched. The climate permits outdoor work during much of the year, and deep warm water routes are at hand for barge transport of massive rocket and spacecraft units between the five facilities.

Management Council Established

On December 31, NASA announced formation of a Management Council to speed work on manned space flight by rapid identification and solution of problems that arise in the course of developing spacecraft, launch vehicles, and support equipment. The Council also serves to clarify such matters as goals, schedules, pacing items, and problems not solely the concern of a single center. Initial members were: D. Brainerd Holmes, Director of Manned Space Flight and Council Chairman; Robert R. Gilruth, Director, Manned Spacecraft Center; Walter C. Williams, Associate Director for Operations, Manned Spacecraft Center; Wernher von Braun, Director, Marshall Space Flight Center; Eberhard F. M. Rees, Deputy Director for Research and Development, Marshall Space Flight Center; and the following from the Office of Manned Space Flight, NASA Headquarters: George M. Low, Director of Spacecraft and Flight Missions; Milton W. Rosen, Director of Launch Vehicles and Propulsion; and Charles H. Roadman, Director of Aerospace Medicine.

Space Nuclear Propulsion Office Opens Cleveland Extension

In October, the Joint Atomic Energy Commission-NASA Space Nuclear Propulsion Office (SNPO) opened an extension at the Lewis Research Center, Cleveland, Ohio. SNPO Headquarters at Germantown, Md., has delegated the extension office certain technical and procurement tasks in connection with the Rover, a joint AEC-NASA nuclear rocket development program. Lewis Research Center carries out the bulk of field research on employment of nuclear energy for propulsion of and power generation on spacecraft.

Personnel

National Goals Spur Staffing Rise

Reflecting in part the major manpower commitment assumed by the Nation to accelerate its space programs, NASA employment climbed from 17,560 to 19,104 during the report period. Distribution of personnel among NASA units on June 30 and December 31 were as follows:

Organizational unit	*June 30, 1961*	*December 31, 1961*
Ames Research Center	1, 487	1, 548
Flight Research Center	451	497
Goddard Space Flight Center	1, 602	1, 864
Langley Research Center	3, 348	3, 476
Lewis Research Center	2, 785	3, 048
Marshall Space Flight Center	5, 964	6, 054
Manned Spacecraft Center	805	1, 163
Wallops Station	305	374
Western Operations Office	60	84
Headquarters	748	976
AEC–NASA Nuclear Office	5	20
Total	[1] 17, 560	[2] 19, 104

[1] Includes 89 military personnel.
[2] Includes 117 military personnel.

Apportionment by major job categories on December 31 was as follows:

. . . Scientists and engineers in aerospacé technology and related supervisory and management positions: 6,201.

. . . Engineers, mathematicians, and other technical and professional personnel supporting the above group: 234.

. . . Scientific and engineering assistants and technicians such as draftsmen, designers, computers specialists and illustrators: 2,267.

. . . Management positions in procurement, personnel, finance, technical information, education and legal: 1,317.

. . . Clerical and administrative positions: 3,001.

. . . Skilled trades and crafts employees and related skilled, semiskilled and unskilled laborers: 6,084.

Included in the NASA staff are 85 foreign scientists and 117 military personnel on loan from the Armed Services.

These figures do not reflect approximately 3,200 employees of Jet Propulsion Laboratory (Pasadena, Calif.) which is operated for NASA under contract by California Institute of Technology.

Recruitment of Scientists and Engineers Intensified

The growing requirements for scientists and engineers in the Nation's accelerated space program have been accompanied by intensified efforts to recruit qualified people. In an unprecedented move, at least on the part of a Government agency, NASA embarked November 3 on a nationwide recruitment campaign. Teams of scientists and personnel administrators had interviewed thousands of professional people in 12 cities by December 31.

NASA also continued other recruitment measures which are touched on in previous Semiannual Reports to Congress. These include circulation of recruiting teams among about 200 colleges and universities to interview graduating students; establishment of recruiting headquarters at meetings of technical and professional societies; and classified advertising in selected newspapers, and professional and technical journals.

During this report period, more than 1,000 scientists and engineers accepted employment with NASA.

Training Programs Keep Pace With Progress

NASA sponsors training programs to assist beginners and to help experienced employees keep pace with progress in their fields.

Graduate Study

About 750 employees were taking graduate university courses directly applicable to their work under NASA's Graduate Study Training Program. The Government defrays tuition and fees.

Co-op Students

More than 300 university students alternated salaried employment at NASA and study at a university or college under NASA's College Cooperative System. Normally, this program runs for 5 years and when the students are awarded their degrees, they have also acquired about 2 years of NASA experience. Although there are no commitments, almost all graduates of this program join NASA.

Apprentice

About 200 employees were enrolled in the Apprentice Program under which NASA develops highly skilled craftsmen. Apprentices receive class and on-the-job training for a minimum of 4 years, after which they are awarded journeyman certificates approved by the Department of Labor and accredited by the State where given.

NASA Employees Honored

On July 21, the Administrator awarded the NASA Distinguished Service Medal to Virgil I. Grissom for outstanding contributions to space technology. Astronaut Grissom flew the Mercury capsule on the second manned suborbital flight. In December, the U.S. Junior Chamber of Commerce voted Astronaut Grissom as one of the 10 outstanding young men of 1961. Men selected for this honor must be no more than 35 years old.

On October 27, Abe Silverstein, who had served as Director of the former Office of Space Flight Programs in NASA Headquarters, was awarded the NASA Medal for Outstanding Leadership. His citation commended Dr. Silverstein's untiring efforts in formulating, implementing, and directing diverse elements of the NASA space program; developing the space flight centers; and ability to make incisive analyses and sound decisions which earned worldwide respect for him and for NASA. Dr. Silverstein is Director, Lewis Research Center, Cleveland, Ohio.

William J. O'Sullivan was awarded the NASA Medal for Exceptional Scientific Achievement on October 27. He was cited for his concept of inflatable space vehicles, his direction of the design and development of the Echo I communications satellite, and demonstrating the feasibility of communications through use of satellites. Mr. O'Sullivan is Assistant to the Chief, Applied Materials and Physics Division, Langley Research Center, Hampton, Va.

In September, Henry J. E. Reid, retired former Director of Langley Research Center, was awarded the NASA Medal for Outstanding Leadership. He was honored for his leadership in developing and directing the center as an organization which attained worldwide recognition in scientific research in aeronautics and space and in training and developing other recognized scientific leaders; and for his pioneering leadership in research on instruments and laboratory facilities for measuring flight vehicle performance.

On November 29, the President awarded the Harmon International Trophy for Aviators to three test pilots of the X-15 research airplane: Joseph A. Walker of NASA; USAF Maj. Robert M. White; and A. Scott Crossfield of North American Aviation, Inc. The joint award was made for outstanding and extraordinary feats of individual piloting.

On September 2, John V. Becker was presented the Golden Plate Award of the Academy of Achievement for outstanding contributions to the advancement of aerospace sciences. Mr. Becker is Chief, Aerophysics Division, Langley Research Center.

Key Executive Personnel Changes

New Appointments

On September 18, Thomas F. Dixon was appointed Director of Launch Vehicle Programs in NASA Headquarters. In NASA's reorganization of November 1, Mr. Dixon became Deputy Associate Administrator. Mr. Dixon was former Vice President for Research and Engineering, Rocketdyne Division, North American Aviation, Inc.

On July 6, Webb Haymaker was appointed Director of the Life Sciences Research Laboratory at Ames Research Center, Mountain View, Calif. Dr. Haymaker previously served the Government as Chief of the Neuropathology Branch, Armed Forces Institute of Pathology.

Effective November 1, D. Brainerd Holmes was named Director of Manned Space Flight Programs in NASA Headquarters. Mr. Holmes was General Manager, Major Defense Systems Division, Radio Corporation of America.

On December 1, Hiden T. Cox was sworn in as Assistant Administrator for Public Affairs. Dr. Cox was formerly Executive Director of the American Institute of Biological Sciences.

Reassignments

Numerous reassignments of key executive personnel accompanied the major NASA reorganization of November 1. The resulting directors of major program offices and field centers along with their former assignments are presented below.

. . . Homer E. Newell, from Deputy Director, Office of Space Flight Programs, to Director, Office of Space Sciences.

. . . Morton J. Stoller, from Assistant Director for Satellite and Sounding Rocket Programs in the Office of Space Flight Programs, to Deputy Director, Office of Applications.

. . . Abe Silverstein, from Director, Office of Space Flight Programs, to Director, Lewis Research Center, Cleveland, Ohio.

. . . Robert R. Gilruth, from Director, Space Task Group, Hampton, Va., to Director, Manned Spacecraft Center, Houston, Tex.

. . . Edmond C. Buckley, from Assistant Director for Space Flight Operations in the Office of Space Flight Programs, to Director, Office of Tracking and Data Acquisition.

. . . Ira H. Abbott, from Director of the Office of Advanced Research Programs, to Director of the Office of Advanced Research and Technology.

. . . Paul G. Dembling, from Acting Assistant Administrator for Congressional Relations, to Director of Legislative Affairs.

Procurement, Contracts, and Grants

Most Contracts Awarded to Private Industry

Total Procurement

During the 6 months ending December 31, 1961, NASA obligated approximately $630 million for procurement. Procurement actions by NASA Headquarters and its field procurement offices totaled about 56,000.

Awards to Business

Approximately $316 million (50 percent) of the funds obligated represented purchases and contracts placed directly with business. About $23 million (4 percent) represented contracts and research grants awarded to nonprofit institutions or organizations; $122 million (19 percent) were obligated under a contract with the California Institute of Technology for the operation of the Jet Propulsion Laboratory; and $169 million (27 percent) were placed with or through other government agencies.

Ninety percent of the dollar value of procurement requests NASA placed with other government agencies resulted in contracts with industry. About 66 percent of the funds NASA obligated under the Jet Propulsion Laboratory contract was ultimately spent with business. Thus, about 87 percent of NASA's procurement dollars was contracted to private industry.

Competitive Bidding.—Approximately $30 million (9 percent) of the direct awards to business were placed through formal advertising for competitive bids. About $132 million (42 percent) were placed through competitive negotiations: proposals or quotations were solicited from more than one source, and the awards were based on price, design, or technical consideration. Thus, $162 million (51 percent) of the purchases and contracts placed directly with business were based on competitive procedures.

Small Business Participated.—NASA awarded $40 million in purchases and contracts directly to small business firms or about 12 percent of the total direct awards to business. Awards to small business

656299 O—62——11

resulted from about 35 thousand actions, or 66 percent of the total number placed with business firms.

Approximately $6.5 million, representing 276 actions, of the awards to small business resulted from small business set-asides (contracts designated in advance for small business). NASA's subcontracting small business program assures small business firms the opportunity to supply NASA needs to the fullest extent possible, consistent with the purpose of the Space Act. Seventeen major prime contractors reported that they subcontracted approximately 15 percent, on the average, of their awards from NASA to small business. The reports cover first-tier subcontracting only.

NASA Procurement Aided by Other Government Agencies.

About $169 million (27 percent) of NASA's total procurement was placed with or through other government agencies, primarily the Department of Defense. It is NASA policy to avoid duplication of effort and to use its own and DOD resources most effectively and economically. Thus, NASA purchases items through DOD which the military departments, because of their own programs, can buy from industry most economically. For example, NASA procures Mercury-Atlas boosters and hardware through the U.S. Air Force and has awarded contracts through the U.S. Army Corps of Engineers for the construction of the Saturn program launch complex at Cape Canaveral.

Procurement Management

NASA continued to improve procurement management during the period of this report. Procurement policies were discussed and analyzed for all procurement personnel at a conference held in October, and a procurement training course for technical personnel was developed; the first class is scheduled to begin in February 1962.

Procurement regulations were issued setting forth policies and procedures for—

Negotiating contracts for work performed outside the United States by a foreign government or foreign private contractor;

Using government inspection agencies to assist NASA installations judge contractor performance on the quality assurance provisions of contracts;

Terminating contracts for the convenience of the government or for default;

Recognizing a successor-in-interest to government contracts or a change in name of a contractor.

Major Contract Awards

Among the major research and development contracts awarded by NASA during the period were the following:

(1) McDonnell Aircraft Corp., St. Louis. Design and develop Gemini two-man spacecraft. Awarded—$25 million (new letter contract).

(2) McDonnell Aircraft Corp., St. Louis. Capsule, spare parts, ground support equipment, training aids, technical data and other related procurement for Mercury Program. Awarded—$19.1 million; cumulative awards, $119.4 million.

(3) North American Aviation, Inc., Canoga Park, Calif. Design and develop F–1, 1,500,000-pound thrust engine. Awarded—$23.7 million; cumulative awards, $97.6 million; total estimated cost, $124.8 million.

(4) North American Aviation, Inc. Develop J–2, 200,000-pound thrust engine, Liquid Propulsion Program. Awarded—$11.1 million; cumulative awards, $25.3 million; total estimated cost, $68.9 million.

(5) North American Aviation, Inc. Design and developed H–1, 188,000-pound thrust engine, Saturn Program. Awarded—$9.9 million; cumulative awards, $21.4 million; total estimated cost, $37.3 million.

(6) Douglas Aircraft Co., Inc., Santa Monica, Calif. Develop and fabricate Saturn S–IV vehicles and ground support equipment. Awarded—$18.3 million; cumulative awards, $41.5 million; total estimated cost, $70.7 million.

(7) Grumman Aircraft Engineering Corporation, Bethpage, N.Y. Design and develop S–18 orbiting astronomical observatory. Awarded—$10.1 million; cumulative awards, $20.3 million; total estimated cost, $32.1 million.

(8) Ling-Temco-Vought, Inc., Dallas. Scout development and procurement; Structures and Materials Research; Launch Vehicle Technology. Awarded—$8.3 million, cumulative awards, $9.1 million.

(9) Aerojet-General Corp., Azusa, Calif. Phase I—NERVA, nuclear powered rocket engine. Awarded—$6.3 million (new contract).

(10) Western Electric Co., Inc., N.Y. Tracking and ground instrumentation system, Mercury Program. Awarded—$4.6 million; cumulative awards, $65.8 million.

Grants and Research Contracts

NASA activities lie in the most advanced frontiers of science and technology. Consequently, the Agency seeks to encourage scientists and engineers of universities and other institutions to participate actively in its research programs. The Office of Grants and Research Contracts has primary responsibility for developing and maintaining vigorous basic and applied research and development programs in which nonprofit scientific organizations, educational institutions, and industry can participate. The Office is as a central source of information and assistance for organizations wishing to participate in these programs through the medium of unsolicited proposals.

During the report period, this office received 700 unsolicited proposals for research; 162 projects totaling $20.8 million were sponsored; 96 university projects amounted to $9.44, 45 percent of the total; 22 projects of nonprofit scientific research institutions amounted to $6.03, and 21 projects of industrial organizations amounted to $1.56; 23 projects of governmental laboratories and agencies amounted to $3.77. Titles of the awards are listed by state in Appendix F.

Financial Management

Further Improvements Made

During the report period, NASA financial management activity included the administration of appropriated funds and the preparation, review, internal approval, and submission of NASA appropriation estimates for the fiscal year 1963. A change was proposed in the appropriation structure to consolidate under a new appropriation account title, Research, Development and Operations, the activities formerly funded under the appropriations entitled Salaries and Expenses and Research and Development. This change is expected to improve management control and simplify the agency's accounting processes.

The financial management organization made further improvements in accounting and reporting procedures for agency programs. Significant achievements included the following: Bureau of the Budget approval was secured on the Contractor Financial Management Reporting System and steps taken to install the system for all cost-type contracts over $500,000; studies progressed on establishing a centralized data processing capability in NASA Headquarters and on applying ADP techniques to financial management; plans were approved to strengthen the Financial Management Division's system staff as the beginning of a comprehensive program to improve NASA financial management.

The following tables depict the planned program level for the fiscal year 1963, and the actual financial operations of the agency during the first 6 months of fiscal year 1962.

Fiscal Year 1963 Program

This table shows the planned level of effort in the proposed Research, Development and Operation appropriation by program area. This appropriation is the successor to the current Research and Development appropriation, and includes in addition the requirements currently funded under the Salaries and Expenses appropriation. It is anticipated that the Salaries and Expenses title will be discontinued for the fiscal year 1963 and later years. The table also shows the planned level of effort in 1963 in the Construction of Facilities appropriation.

TABLE 5.—*NASA budget estimates, fiscal year 1963*
[In thousands]

Appropriation	*1963 Estimates*	
Research, development and operation:		
Mercury	$13, 259	
Advanced manned space flight	863, 628	
Saturn C-1	249, 237	
Advanced Saturn	335, 172	
Nova	163, 574	
Meteorological satellites	51, 185	
Communications satellites	85, 377	
Sounding rockets	19, 157	
Scientific satellites	175, 165	
Lunar and planetary exploration	273, 560	
Scout	8, 947	
Delta	268	
Centaur	66, 664	
Spacecraft technology	54, 084	
Launch vehicle technology	31, 690	
Launch operations development	21, 486	
Electric propulsion	30, 647	
Liquid propulsion	163, 102	
Solid propulsion	7, 944	
Space power technology	20, 172	
Nuclear systems technology	122, 962	
Aircraft and missile technology	52, 588	
Tracking and data acquisition	158, 410	
Total, research, development and operation		$2, 968, 278
Construction of facilities		818, 998
Total		$3, 787, 276

Financial Report, December 31, 1961

This table sets forth the total amount of funds obligated and expended during the first 6 months of fiscal year 1962, together with actions pending on December 31, 1961. A summary by appropriation giving current availability, December 31 obligations and commitments against this availability, and December 31 uncommitted balances is appended.

TABLE 6.—*Status of fiscal year 1962 appropriations as of Dec. 31, 1961*

[In thousands]

Appropriations	*Total obligations*	*Pending commitments*	*Total expenditures*
Salaries and expenses	$99, 394	$1, 923	$93, 593
Research and development:			
Support of NASA plant	43, 525	23, 702	33, 792
Research grants and contracts	1, 698	1, 554	2, 917
Life sciences	6, 314	2, 294	1, 806
Sounding rockets	4, 030	4, 841	4, 675
Scientific satellites	21, 055	16, 198	26, 147
Lunar and planetary exploration	93, 986	2, 514	42, 540
Meteorological satellites	18, 673	4, 048	12, 766
Communications satellites	5, 981	11, 369	5, 360
Spacecraft technology	5, 224	7, 824	2, 709
Space power technology	3, 480	738	2, 337
Mercury	11, 776	20, 260	24, 616
Apollo	30, 498	49, 077	1, 291
Launch vehicle technology	2, 718	4, 080	4, 432
Launch operations development	259	104	99
Solid propulsion	930	91	670
Liquid propulsion	33, 688	9, 236	35, 812
Electric propulsion	916	370	144
Nuclear systems	12, 072	5, 053	7, 343
Scout	1, 899	2, 741	2, 760
Delta	344	1, 196	4, 152
Centaur	20, 587	14, 615	18, 121
Saturn	84, 276	31, 739	60, 416
Nova	--------	--------	--------
Vega	--------	--------	426
Vehicle procurement	44, 262	39, 133	33, 688
Tracking and data acquisition	35, 029	15, 903	17, 067
Reimbursable—other agencies	2, 480	17, 153	2, 631
Total, research and development	485, 700	285, 833	348, 717
Construction of facilities	112, 430	27, 543	36, 915

Appropriation summary	*Current availability*	*Total, obligations and commitments*	*Uncommitted balance*
Salaries and expenses	$221, 600	$101, 317	$120, 283
Research and development	1, 304, 198	771, 533	532, 665
Construction of facilities	345, 337	139, 973	205, 364
Total	1, 871, 135	1, 012, 823	858, 312

Other Activities

Scope of Chapter

This chapter reports on significant developments in NASA educational, technical information, and contributions awards programs and in interagency cooperation and coordination.

Educational Programs

NASA's educational services are designed to explain the projects, goals, and underlying scientific and engineering principles of its programs; assist educators in orienting curricula to the Space Age; and promote development of young people to satisfy the Nation's future needs for scientists and engineers. Demands for these services are growing as a result of rising public interest in the space program and the increasing concern of educators with meeting requirements imposed by rapidly advancing technology. Types of assistance available from NASA and developments in each area during this period are described below.

Spacemobile

Spacemobile demonstrations during this period totaled 1,200. These popular and effective educational devices visited almost every State, including Alaska, and the Commonwealth of Puerto Rico. They were one of the features of numerous summer aerospace education workshops conducted by colleges and universities.

By September, NASA's four Spacemobiles had been booked through the 1961–62 school year, and demand was climbing at a far greater rate than could be satisfied by existing vehicles. As a result, plans were made to add five more units at an early date.

Spacemobiles are traveling space science demonstrators sufficiently versatile to serve audiences from elementary school pupils to adults. Each has a qualified lecturer who employs models and other graphic devices to describe achievements and aims of the U.S. space program and the basic engineering and scientific technology involved. A typical presentation takes about 50 minutes.

Workshops and Other Programs

NASA assisted numerous colleges and universities in organizing and conducting workshops and other programs of aerospace education for teachers and school administrators. Among services provided were lectures by scientists and educators on the NASA staff, scientific demonstrations, and exhibits, educational publications, motion pictures, slides, and other visual aids.

Exhibits

Requests for NASA exhibits increased every month. During the period, the Agency booked 130 displays, ranging in size from tabletop units to presentations covering several thousand square feet. Major showings: Smithsonian Institution, Washington, D.C. (estimated 170,000 viewers); Canadian National Exposition, Toronto, Canada, (500,000); Southwest Nuclear Energy Symposium, Hot Springs, Ark., (30,000); Oklahoma State Fair, Oklahoma City, Okla., (550,000); and American Rocket Society Space Flight Report to the Nation, Coliseum, New York City, (35,000).

Fourteen Mercury exhibits were on continuous display at selected locations. Each featured a full-scale reproduction of the Mercury capsule containing a manikin astronaut in space suit. This was shown in conjunction with panels depicting the Mercury program which is determining man's ability in and reaction to orbital flight, and the Apollo project to land men on the moon and return them safely to earth.

"Freedom 7," the Mercury spacecraft in which Astronaut Alan B. Shepard, Jr., made his historic suborbital rocket flight, was presented to the Smithsonian Institution on October 23, where it is on permanent display.

NASA is readying a new technical exhibit for initial public showing at the Century 21 exposition to open in Seattle, Wash., April 21, 1962. In 19,600 square feet, the Century 21 management plans to set up models of NASA spacecraft, launch vehicles, and engines—some full-scale—and illustrative panels depicting the scope and breadth of United States space program and its underlying scientific and engineering technology.

Publications

NASA's educational publications program is designed to bridge the gulf between advances in aeronautics and space and their treatment in textbooks. "Spacecraft," released in December, inaugurated a paperback series on space science jointly supported by NASA and the National Science Teachers Association. The 160-page publication, aimed at high school readers, describes NASA programs and goals in space. "Spacecraft" was first distributed to science and mathematics teachers and to chapter leaders of Future Scientists of America, a high school student organization promoting interest in science as a career.

During the period, NASA completed the following educational publications: "Exploring Space—Projects Mercury and Apollo," "This is NASA," "The Flight of Astronaut Grissom and Liberty Bell 7," "The X–15 Research Airplane," "Pioneer V," and "Aeronautics and Space Bibliography for Secondary Grades." The latter is the second in a series for elementary and secondary students and adult reading.

Reprints of the following were acquired and distributed: "The Practical Values of Space Exploration" (revised August 1961), a report of the Committee on Science and Astronautics of the House of Representatives; IGY Bulletin 49, a publication of the National Academy of Sciences (Project Mercury); "Countdown for Space" and "America's First Manned Venture into Space" from the National Geographic Magazine; "Why Spend $20 Billion to go to the Moon," an interview with NASA Administrator James E. Webb appearing in U.S. News and World Report.

NASA provides limited quantities of educational publications without charge to teachers, students, and the general public, upon request.

Motion Pictures

NASA is preparing a series of scientific films for use on educational television stations, on public service programs of commercial television stations and networks, in classrooms, and before civic and professional societies. Among films produced during this period were: Professional level: "How Did Life Begin?", "The Chemistry of Life," "Life on Other Planets," "Decontamination of Space Vehicles;" General level: "Astronaut Shepard Reports on Space," and "Flight of Freedom 7."

NASA also catalogued about 2¼ million feet of stock film so that it could be made available to educational and documentary film producers. In response to news media and other requests, about 125,000 feet of film, including such scenes as rocket launches and satellite preparation and operation, were released.

History

The NASA historical staff continued to assemble and collate documents and papers of Project Vanguard, preparatory to writing a complete history of the first United States scientific satellite program. It also reviewed papers of John F. Victory, Executive Secretary of the National Advisory Committee for Aeronautics (NACA), NASA's predecessor agency, and other historical materials.

NASA Open House at Langley

About 10,000 visitors attended an open house held October 7, at NASA's Langley Research Center, Hampton, Va. They observed research equipment and facilities used for NASA studies and viewed exhibits and motion pictures on NASA aeronautic and space activities. Demonstrations included operation of one of several wind tunnels for about 10 seconds in each hour. Among the displays were a duplicate of the 12-foot diameter Explorer IX balloon satellite and a one-fifth scale model of the Saturn C–1 launch vehicle.

Scientific and Technical Information

Documentation Facility

On December 1, NASA selected Documentation, Inc., Washington, D.C., one of 17 organizations submitting proposals in response to an Agency invitation, as the firm with which to negotiate a contract to establish and operate a mechanized scientific and technical information center. Such an automated facility is required to store and make readily available the rapidly increasing amounts of data related to space and aeronautics.

The contractor is expected to select and acquire documentary materials to supplement the NASA collection; abstract and index; prepare printed announcements and indices of newly-acquired literature; provide reference support; and compile bibliographies in specialized fields. The center is intended to serve not only NASA but also NASA contractors and other participants in the U.S. space program. NASA will continue to provide technical report materials and bibliographic tools to other members of the scientific community on request.

Support of Abstracts and Bibliographies

NASA continued fiscal support of abstracting and bibliographic work in two subject areas of immediate concern to its research programs. In cooperation with the U.S. Air Force and the Federal Aviation Agency, NASA contributed financial support to the Library of Congress for the preparation of abstracts pertinent to aerospace medicine and biology literature. NASA, as in the past, assumed responsibility for publishing and distributing the abstracts. Current abstracts are published in "Aerospace Medicine." Retrospective abstracts are published annually in "Medicine and Biology, an Annotated Bibliography."

The American Meteorological Society received NASA support to prepare upper atmosphere and space science literature abstracts, which are published in "Meteorological and Geoastrophysical Abstracts."

Dissemination of NASA Technical Literature

Scientific and technical results of NASA experiments were made available to scientists both here and abroad through a variety of media: Technical Reports, Technical Notes, published proceedings of meetings and conferences, and papers printed in professional journals.

NASA distributed 19 unclassified Technical Reports and 170 unclassified Technical Notes to a regular mailing list of about 1,700 addressees in industrial, research, and other Government organizations involved in the space program. Additional copies were made available for sale to the public at the Government Printing Office (for Technical Reports) and the Office of Technical Services, Department of Commerce (Technical Notes). NASA issued 54 classified Technical Memorandums to authorized recipients in Government and private organizations.

More than 200 NASA research and development papers were presented at scientific conferences or appeared in technical journals. In addition, NASA published the proceedings of the Image Intensifier Symposium, the International Meteorological Satellite Workshop, the Symposium on Acceleration Stress, and the "Results of the Second U.S. Manned Suborbital Space Flight, July 21, 1961."

Scientific Translations

Under its comprehensive foreign technical literature translation program, NASA published 10 technical translations and made 70 other translations of interest to specific activities. The technical translations are on sale at the Office of Technical Services, Department of Commerce.

NASA also prepared a Translations List cataloguing aeronautics- and space-related translations by NASA and other Government agencies. The list, which includes translations completed and underway, is used internally and distributed to NASA contractors and other Government agencies.

Arrangements have been made with private sources and other Government agencies to exchange translations and information concerning translations finished and in process.

Dictionary of Space Terms

Drafts of the NASA "Dictionary of Space Terms" were circulated for review to NASA technical staff members and others. The dictionary is intended as a current scientific reference and a guide for persons unfamiliar with space technology. It is scheduled for publication in 1962.

Compatibility in Information Retrieval Systems

NASA is represented in an interagency group organized by the National Science Foundation to study language compatibility in mechanized storage and retrieval systems. Such a development would facilitate rapid exchange of scientific information between computer systems of different agencies.

Contributions Awards

On November 16, the Administrator awarded $5,000 to William J. O'Sullivan, Assistant to the Chief, Applied Materials and Physics Division, Langley Research Center. Mr. O'Sullivan originated the concept of inflatable space structures and directed design and development of the Echo I communications satellite.

Mr. O'Sullivan's was the second award made under the Contributions Awards authority of the National Aeronautics and Space Act of 1958. The first was made in January to Frank T. McClure of Johns Hopkins University for his satellite doppler navigation system used in the Navy's Transit navigation satellite program.

The NASA Inventions and Contributions Board (see app. D for membership) evaluates for such awards scientific and technical contributions, whether patentable or unpatentable, received from any person as defined in section 305 of the Space Act. During the report period, the board received 2,071 communications and evaluated 936 contributions.

Under the Incentive Awards Act of 1954, the board approved monetary awards to 24 NASA employees for 15 inventions.

Interagency Cooperation and Coordination

Interagency cooperation and coordination reduce needless duplication of efforts and facilities and advance employment of Government resources. Typical cooperative enterprises in which NASA engaged during this period follow:

National Operational Meteorological Satellite System

According to plans made during this report period, NASA will cooperate extensively with the Weather Bureau in the activities of the National Operational Meteorological System, discussed in Chapter 3, "Satellite Applications".

International Meteorological Satellite Workshop

From November 13 through 22, NASA and the Weather Bureau held an International Meteorological Satellite Workshop in Washington, D.C. About 39 meteorologists from 27 nations received instructions on interpreting weather satellite data.

Supersonic Transport

On July 24, the Federal Aviation Agency, Department of Defense, and NASA jointly released their "Commercial Supersonic Transport Aircraft Report". The study confirmed the feasibility of a supersonic air transport and urged the United States to undertake a program which would lead to an operational supersonic airliner during the 1970's. Basic research studies related to the transport are in progress. FAA is providing leadership and fiscal support; NASA, basic research and technical support; and DOD, through the U.S. Air Force, administrative and technical support.

Conference on Slush-Covered Runways

On December 19 and 20, NASA and the FAA sponsored an aviation industry conference in Washington, D.C., on problems of runway slush, after snowfall, in jet takeoff and landing. The two agencies reported results of tests conducted on this hazard.

Nuclear Rocket Development

The joint Atomic Energy Commission-NASA Space Nuclear Propulsion Office continued its task of coordinating the work of the two agencies in developing nuclear rocket systems for space exploration. The office, after review of a contractor study, recommended a site at Jackass Flats, approximately 60 miles northwest of Las Vegas, Nev., for a Nuclear Rocket Development Station. The recommendation and others concerning the station were submitted to the NASA Administrator and to the AEC for approval.

NASA–DOD Large Launch Vehicle Planning Group

In July, the Secretary of Defense and the NASA Administrator established the NASA–DOD Large Launch Vehicle Planning Group. The group's purpose is to seek methods of avoiding duplication in the National Launch Vehicle Program by selecting a limited number of basic boosters able to meet civilian or military requirements. Among the group's accomplishments during this period was the selection of the U.S. Air Force Titan II as the launch vehicle for NASA's two-man Gemini spacecraft, thus avoiding costly and time-consuming development of a new launch vehicle.

Smithsonian Astrophysical Observatory

The Smithsonian Astrophysical Observatory continued to provide NASA with valuable data based upon satellite observations made by its worldwide network of Baker-Nunn cameras and volunteer Moonwatch stations. The Smithsonian is also assisting in NASA's Orbiting Solar and Astronomical Observatory programs in which the sun and other parts of the universe are to be studied by instruments in unmanned satellites.

Project Mercury

Recovery forces of the U.S. Navy were deployed across the Atlantic Ocean during Mercury experiments conducted in this period. On July 21, these forces rescued Astronaut Grissom after the second U.S. manned suborbital space flight. On September 13, they recovered an unmanned Mercury capsule that had made a single orbit and landed in the Atlantic. And on November 29, the Navy recovered a capsule and its occupant, a chimpanzee named Enos, after a two-orbit flight. Enos was trained by the U.S. Air Force.

Appendix A

MEMBERSHIPS OF CONGRESSIONAL COMMITTEES ON AERONAUTICS AND SPACE

(*July 1, 1961–December 31, 1961*)

Senate Committee on Aeronautical and Space Sciences

ROBERT S. KERR, Oklahoma, *Chairman*
RICHARD B. RUSSELL, Georgia
WARREN G. MAGNUSON, Washington
CLINTON P. ANDERSON, New Mexico
STUART SYMINGTON, Missouri
JOHN STENNIS, Mississippi
STEPHEN M. YOUNG, Ohio
THOMAS J. DODD, Connecticut
HOWARD W. CANNON, Nevada
SPESSARD L. HOLLAND, Florida

ALEXANDER WILEY, Wisconsin
MARGARET CHASE SMITH, Maine
CLIFFORD P. CASE, New Jersey
BOURKE HICKENLOOPER, Iowa

House Committee on Science and Astronautics

GEORGE P. MILLER, California, *Chairman*
OLIN E. TEAGUE, Texas
VICTOR L. ANFUSO, New York
JOSEPH E. KARTH, Minnesota
KEN HECHLER, West Virginia
EMILIO Q. DADDARIO, Connecticut
WALTER H. MOELLER, Ohio
DAVID S. KING, Utah
J. EDWARD ROUSH, Indiana
THOMAS G. MORRIS, New Mexico
BOB CASEY, Texas
WILLIAM J. RANDALL, Missouri
JOHN W. DAVIS, Georgia
WILLIAM F. RYAN, New York
JAMES C. CORMAN, California
JOHN W. MCCORMACK, Massachusetts

JOSEPH W. MARTIN, JR., Massachusetts
JAMES G. FULTON, Pennsylvania
J. EDGAR CHENOWETH, Colorado
WILLIAM K. VAN PELT, Wisconsin
PERKINS BASS, New Hampshire
R. WALTER RIEHLMAN, New York
JESSICA MCC. WEIS, New York
CHARLES A. MOSHER, Ohio
RICHARD L. ROUDEBUSH, Indiana
ALPHONZO E. BELL, California
THOMAS M. PELLY, Washington

656299 O—62——12

Appendix B

Membership of the National Aeronautics and Space Council

(July 1, 1961–December 31, 1961)

LYNDON B. JOHNSON, *Chairman*
Vice President of the United States

DEAN RUSK
Secretary of State

ROBERT S. MCNAMARA
Secretary of Defense

JAMES E. WEBB, *Administrator*,
National Aeronautics and Space Administration

GLENN T. SEABORG, *Chairman*,
Atomic Energy Commission

Executive Secretary
EDWARD C. WELSH

Appendix C

Membership of the NASA-DOD Aeronautics and Astronautics Coordinating Board and Vice-Chairmen of Panels to Board

(*December 31, 1961*)

Chairman

Dr. HUGH L. DRYDEN, Deputy Administrator, NASA

Co-chairman

Dr. HAROLD BROWN, Director of Defense Research and Engineering

Members at Large

Dr. ROBERT C. SEAMANS, JR., Associate Administrator, NASA
Dr. FINN LARSEN, Assistant Secretary of the Army

Manned Space Flight Panel

Board Member and Chairman: D. BRAINERD HOLMES, Director of Manned Space Flight Programs, NASA

Vice Chairman: Dr. JOSEPH V. CHARYK (*Acting*), Under Secretary of the Air Force

Unmanned Spacecraft Panel

Board Member and Chairman: Mr. MORTON J. STOLLER, Deputy Director, Office of Applications, NASA

Vice Chairman: Mr. JOHN H. RUBEL, Assistant Secretary of Defense and Deputy Director of Defense Research and Engineering

Launch Vehicles Panel

Board Member and Chairman: Hon. BROCKWAY MCMILLAN, Assistant Secretary of the Air Force

Vice Chairman: THOMAS F. DIXON, Deputy Associate Administrator, NASA

Space Flight Ground Environment Panel

Board Member and Chairman: Brig. Gen. PAUL T. COOPER, USAF, Acting Assistant Director of Defense Research and Engineering (Ranges and Space Ground Support)

Vice Chairman: EDMOND C. BUCKLEY, Director of Tracking and Data Acquisition, NASA

Supporting Space Research and Technology Panel

Board Member and Chairman: Mr. IRA H. ABBOTT, Director of Advanced Research Programs, NASA

Vice Chairman: Mr. JOHN B. MACAULEY, Assistant to Director of Defense Research and Engineering

Aeronautics Panel

Board Member and Chairman: Vice Adm. WILLIAM F. RAYBORN, USN, Deputy Chief of Naval Operations

Vice Chairman: Mr. MILTON B. AMES, Director of Space Vehicles, NASA

Secretariat

Secretary for DOD: Dr. O. F. SCHUETTE

Secretary for NASA: Mr. WILLIAM J. UNDERWOOD, Office of the Administrator, NASA

Appendix D

Membership of NASA Inventions and Contributions Board

(July 1, 1961–December 31, 1961)

Chairman

ROBERT E. LITTELL, Assistant for Facilities, Office of Advanced Research Programs.

Vice Chairman

PAUL G. DEMBLING, Director, Office of Legislative Affairs, Office of the Administrator.

Members

ELLIOT, MITCHELL, Assistant Director for Propulsion, Office of Launch Vehicle Programs.[1]

J. ALLEN CROCKER, Chief, Coordinator for Lunar and Planetary Programs, Office of Space Flight Programs.

C. GUY FERGUSON, Assistant Classification and Organization Officer, Personnel Division, Office of Administration.

Executive Secretary

JAMES A. HOOTMAN, NASA Inventions and Contributions Board.

---

[1] Resigned Nov. 29, 1961.

Appendix E

MEMBERSHIPS OF NASA SPACE SCIENCES STEERING COMMITTEE AND SUBCOMMITTEES

(*December 31, 1961*)

Space Sciences Steering Committee [1]

Chairman: HOMER E. NEWELL

Executive Secretary: MARGARET B. BEACH

Members

JOHN F. CLARK
EDGAR M. CORTRIGHT
FREEMAN H. QUIMBY
CHARLES P. SONETT
JESSE L. MITCHELL
ORAN W. NICKS

Liaison

E. C. BUCKLEY (H. R. BROCKETT) [2]
M. J. STOLLER (JACK POSNER)
A. FRUTKIN (RICHARD BARNES)
T. L. SMULL

Subcommittees [1]

AERONOMY

Chairman: MAURICE DUBIN

Secretary: M. J. AUCREMANNE

Members

CHARLES A. BARTH
BERTRAM DONN
R. F. FELLOWS
ANDREW E. POTTER, JR.
NELSON W. SPENCER

Liaison

SPENCER FRARY (MSFC)
RICHARD A. HORD (Langley)

Consultants

DR. WILLIAM W. KELLOG
J. W. CHAMBERLAIN
HERBERT FRIEDMAN
RICHARD N. GOODY
KENICHI WATANABE
FRED J. WHIPPLE

[1] Committee and subcommittee members are on the NASA staff.
[2] The second individual is an alternate.

ASTRONOMY

Chairman: NANCY G. ROMAN

Secretary: ERNEST J. OTT

Members

ROBERT COATES
JAMES E. KUPPERIAN
JOHN C. LINDSAY
RAYMOND NEWBURN

Liaison

DAVID ADAMSON (Langley)
WILLIAM E. BRUNK (Lewis)
ROBERT T. JONES (Ames)
CHARLES LUNDQUIST (MSFC)

Consultants

DR. DIRK BROUWER
PROF. WILLIAM F. FOWLER
DR. DAVID S. HEESCHEN
DR. A. KEITH PIERCE
DR. BENGT STROMGREN
DR. RICHARD TOUSEY

BIOSCIENCE

Chairman: FREEMAN H. QUIMBY

Secretary: RICHARD S. YOUNG

Members

S. J. GERATHEWOHL
G. J. JACOBS
JACK POSNER
G. D. SMITH

Liaison

C. FRICTEL
J. H. GRAHAM
GEORGE HOBBY (JPL)
H. SMEDAL (Ames)
R. STONE (Langley)

Consultants

DR. MELVIN CALVIN
DR. SIDNEY W. FOX
DR. NORMAN H. HOROWITZ
DR. C. S. PITTENDRIGH
DR. ERNEST C. POLLARD
DR. CARL E. SAGAN

IONOSPHERIC PHYSICS

Chairman: JOHN F. CLARK

Secretary: FREDERICK C. GRACELY

Members

DR. SIEGFRIED BAUER
ROBERT E. BOURDEAU
JOHN E. JACKSON

Liaison

GABRIEL ALLEN (Lewis)
OTTO HOBERG (MSFC)
JOHN R. SPREITER (Ames)
GEORGE P. WOOD (Langley)

Consultants

Prof. Robert A. Helliwell
Dr. Hans E. Hinteregger
Dr. Francis S. Johnson
Dr. C. Gordon Little
Dr. E. R. Schmerling
Prof. George W. Swenson, Jr.

LUNAR SCIENCES

Chairman: Charles P. Sonett

Secretary: Newton W. Cunningham

Members

George Bocher
Manfred Eimer
Albert R. Hibbs
Leslie H. Meredith
Robert Jastrow

Liaison

Donald E. Gault (Ames)
Earl W. Conrad (Lewis)
John C. Houbolt (Langley)

Consultants

Dr. Harrison Brown
Dr. Maurice Ewing
Dr. Thomas Gold
Dr. H. H. Hess
Dr. Frank Press
Dr. Harold C. Urey

PARTICLES AND FIELDS

Chairman: John E. Naugle

Secretary: Robert F. Fellows

Members

Michel Bader
Joseph C. Cain
Frank B. McDonald
Hugh Anderson

Liaison

James W. Blue (Lewis)
Clinton E. Brown (Langley)
Russell D. Shelton (MSFC)

Consultants

Dr. Kinsey A. Anderson
Dr. Thomas Gold
Dr. Eugene N. Parker
Prof. Bruno B. Rossi
Prof. James A. Van Allen
Dr. John R. Winckler

PLANETARY AND INTERPLANETARY SCIENCES

Chairman: CHARLES P. SONETT

Secretary: ROGER C. MOORE

Members

PAUL J. COLEMAN, Jr.
RICHARD DAVIES
MAURICE DUBIN
MANFRED EIMER
ALBERT R. HIBBS
HERMAN E. LAGOW
LESLIE H. MEREDITH
RICHARD S. YOUNG

Liaison

DEAN R. CHAPMAN (Ames)
SAMUEL KATZOFF (Langley)
GERALD MORRELL (Lewis)
ERNST STUHLINGER (MSFC)

Consultants

Dr. PHILIP H. ABELSON
Dr. J. W. CHAMBERLAIN
Dr. GERARD P. KUIPER
Dr. JOSHUA LEDERBERG
Dr. EDWARD P. NEY
Dr. GERHARD F. SCHILLING
Dr. LEVERETT DAVIS, Jr.
Dr. FRED T. HADDOCK

Appendix F

Grants and Research Contracts Initiated From July 1 Through December 31, 1961

[Contracts have prefix NAS; grants have prefix NsG; transfer of funds to Government agencies have prefix R]

State and grant or contract No.	Organization and purpose	Investigator	Amount
ALASKA			
NsG-201	University of Alaska Conduct a theoretical study of the ring current and geomagnetic field phenomena.	Sydney Chapman	$20,000
ARIZONA			
NsG-191	University of Arizona Conduct research on human information processing capacity with single and dual sensory channels.	Neil R. Bartlett	24,468
ARKANSAS			
NsG-153	University of Arkansas Basic experimental research leading to improved cold electron sources and new types of velocity filter mass spectrometers.	M. K. Testerman	37,000
CALIFORNIA			
NASr-66	Aerojet-General Corp Conduct research to develop, insofar as possible, from consideration of determinable variables in liquid rocket engine design, theoretical and practical techniques for quantitative prediction of rocket engine system reliability and reliability potential.	James H. Madden	47,115
NASr-8	Astro Research Corp A theoretical and experimental study of toroidal filamentary pressurized structures based on isotensoid design concepts, including initial studies of failure mechanisms, collapsibility and possible application of isotensoid concepts to the design of space structures.	H. R. Schuerch	60,313
NASr-76	Beckman Instruments, Inc Conduct research for development, construction and testing of a bread board model and design prototype of a spaceborne gas chromatograph instrument and the construction delivery and preflight testing of a final flight unit.	M. R. Burnell	238,273
NsG-97	University of California (Berkeley) Studies of Inert Gases in Meteorites, and Arrhenius X-ray Diffraction and Gamma Ray Detection Techniques for Lunar Exploration.	Arnold Suess	31,174
NsG-139	University of California (Berkeley) Research on techniques and instrumentation for measurement of physiological variables in mammals under space flight conditions.	H. B. Jones	590,000

State and grant or contract No.	Organization and purpose	Investigator	Amount
CALIFORNIA—con.			
NsG-150	University of California (Berkeley) Dynamic behavior of porous electrode systems.	Charles W. Tobias	$70,000
NsG-154	University of California (Berkeley) Neurophysiological, neurochemical, and systemic effects in rats subjected to prolonged sensory deprivation.	George Rosenfeld	46,000
NsG-40	California Institute of Technology Investigation of fluid mechanics of rarified gases by extending shock techniques into the low pressure regime.	H. P. Liepmann	120,000
NsG-56	California Institute of Technology Investigation of the problems of lunar and planetary exploration.	H. Brown	20,775 142,500
NsG-172	California Institute of Technology Conduct experimental and theoretical research on failure criteria for viscoelastic materials typical of solid rocket propellants.	M. L. Williams	26,675
NASw-81	California Institute of Technology Investigation of the Moon with a lunar seismograph station.	H. Benioff	163,000
NASr-75	General Atomic Perform neutron and photoneutron activation analyses of chondritic, achondritic, and oron meteorites and of terrestrial core drillings to determine their rare-earth abundances and, for some, their isotopic ratios and rare-earth homogeneities.		52,418
NASr-59	Lockheed Aircraft Corp Conduct an investigation to develop, design and operating procedures to minimize fuel vent fires due to lightning.	Melvin Gerstein	203,331
NAS5-1120	Marquardt Corp Feasibility study of a continuous flow magnetogasdynamic rocket for space propulsion.		73,021
NASr-21(02)	Rand Corp Conduct (*a*) studies of operational factors and economic potential of passive spherical communication satellite systems, etc.; conduct (*b*) studies of operational factors and economic potential of 24-hour active communication satellite systems, etc.		309,316
NASr-21(04)	Rand Corp Conduct studies to derive a consistent set of fundamental constants and prepare preliminary tables of the values of constants and of parameters of the solar systems, etc.	G. F. Schilling	74,825
NASr-21(05)	Rand Corp Conduct theoretical studies of the earth's magnetic field and the space environment near earth.	E. H. Vestine	149,630
NsG-178	University of Southern California Interactions of vacuum ultraviolet radiation with solid materials.	G. L. Weissler	103,900
NASr-56	Space Technology Laboratories, Inc Conduct an experimental investigation of the behavior of thin-walled cylindrical shells subjected to constant axial loads simultaneously with rapidly varying lateral external pressures.	M. V. Barton	18,100
NsG-30	Stanford University Investigation of ionospheric electron content and long range radio propagation.	O. K. Garriott	132,600
NsG-52	Stanford University Convection heat transfer in annular passages with and without asymmetric heating and eccentricity (Cont. of NAw 6554).	William C. Reynolds	12,265

State and grant or contract No.	Organization and purpose	Investigator	Amount
NsG-174	Stanford University Conduct investigation of experimental techniques for measurement of very low frequency electromagnetic phenomena in the ionosphere.	R. A. Helliwell	$44,938
NsG-215	Stanford University Physiological mechanisms, including periodic phenomena, involved in the adaptation of humans to monotonous environments.	Lenore Morrell	60,023
NsG-218	Stanford University Molecular evolution in protobiological systems, including a search for catalysts and catalytic activity in the intermediate systems which form during the syntheses of low molecular weight organic compounds.	N. S. Blois	86,800
NASr-49(01)	Stanford Research Institute Conduct (*a*) measurement of the internal interference characteristics of the existing operating payload in an available satellite in the solar observatory program, (*b*) development of multichannel instrumentation, including antenna, receiving system, etc., (*c*) analysis of the results of the rocket flights.	Robert Helliwell	186,952
NASr-49(02)	Stanford Research Institute (*a*) Investigation of potential interference between ground microwave communications and proposed satellite communication systems on shared frequency bands. This study shall include determination of spectrum separation requirements, development of mathematical models of ground and satellite systems, etc.	W. R. Vincent	146,666
NASr-49(03)	Stanford Research Institute Determine the general shape and condition of the *Echo I* satellite by means of direct high resolution photograph.	R. H. Weitbrecht	10,282
COLORADO			
NASr-86	University of Colorado Conduct investigation of the solar ultraviolet radiation.	William A. Rense	250,000
NsG-207	University of Denver Identification of tangible economic nonspace byproducts of space research and development efforts, including current applications of past research and potential future applications of current research; evaluation of byproduct identification techniques; and study of information flow from space research to commercial application.	John G. Welles	56,745
CONNECTICUT			
NsG-204	University of Connecticut Analytical and experimental heat transfer studies of moving vapor condensing in small tubes.	W. E. Hilding	56,920
NASr-64	Dunlap and Associates, Inc. Conduct research directed toward establishing human factors criteria and control-navigation display system requirements for spacecraft missions.	Roland C. Casperson	63,900
NASw-95	General Dynamics Corp. Photosynthetic gas exchanger.	Herman E. Sheets	151,524

State and grant or contract No.	Organization and purpose	Investigator	Amount
CONNECTICUT—con.			
NsG-82	Yale University Steady state interaction between radiation and matter in stellar atmospheres.	Rupert Wildt	$55,000
NsG-163	Yale University Theoretical research in relativity, cosmology and the physics of stellar interiors.	Vernon W. Hughes	15,620
NsG-176	Yale University Conduct investigations of the interaction of solar flare particles with the coronal plasma.	Ludwig Oster	11,955
NsG-192	Yale University Conduct research on gas chromatographic systems to analyze certain chemical constituents of the surface of the moon.	Seymour R. Lipsky	97,640
NsG-208	Yale University Conduct a determination and analysis of the properties and characteristics of extremely small free-living self-replicating cells.	Harold J. Morowitz	38,196
FLORIDA			
NsG-148	Florida State University Peripheral mechanisms of human temperature sensitivity.	D. R. Kenshalo	21,510
NsG-173	Florida State University Conduct research in space biology and relevant physical aspects of planetary and space environments.	Sidney Fox	784,000
R-37	U.S. Navy—School of Aviation Medicine An investigation of physiological and psychological responses to the force environments generated by rotational motions occurring in the operation of aircraft and space vehicles (Cont. of R-1).	Ashton Graybiel	284,661
R-39	U.S. Navy—School of Aviation Medicine Conduct research on the effect of very strong magnetic fields and of magnetic-field-free environments on man and animals.	D. E. Beischer	23,100
R-47	U.S. Navy—School of Aviation Medicine An investigation of physiological and psychological responses to the force environments generated by rotational motions occurring in the operation of aircraft and space vehicles (Cont. of R-37).	Ashton Graybiel	1,436,000
R-53	U.S. Navy—School of Aviation Medicine Physiological responses to alterations in weight.	A. H. Smith	147,400
ILLINOIS			
NASr-65(01)	Armour Research Foundation Conduct a theoretical and experimental study of the radiative properties of simulated Martian and Venusian atmospheres, and at the aerodynamic heating of space vehicles entering these atmospheres.	William O. Davies	63,335
NsG-96	University of Chicago Theoretical investigation of further consequences of solar wind.	E. N. Parker	56,271
NsG-144	University of Chicago Conduct high altitude balloon measurements of the electron, low energy proton, and alpha particle spectrum of the primary cosmic radiation during 1961.	Peter Meyer	98,300

State and grant or contract No.	Organization and purpose	Investigator	Amount
NsG-179	University of Chicago Conduct experimental and theoretical studies of energetic particles and electrodynamical processes in interplanetary space and in the vicinity of planets.	John Simpson	$420,000
NsG-24	University of Illinois Investigation of the ionosphere using signals from earth satellites.	G. W. Swenson, Jr.	80,124
NsG-195	University of Illinois Conduct an experimental analysis of the microneuroanatomy of the central nervous system.	William J. Fry	316,293
IOWA			
NsG-62	Iowa State University Application of blade element techniques to the design and performance prediction problems for axial flow pumps (Cont. of NAw-6518).	G. K. Serovy	14,270
NASr-73	State University of Iowa Conduct experimental investigation of a unique gas permeability cell system to remove CO_2 and other noxious gases from spacecraft cabins.	Coleman J. Major	38,400
MARYLAND			
NsG-193	Johns Hopkins University Conduct rocket and laboratory experiments and analysis on the ultraviolet spectra of the upper atmosphere.	G. H. Dieke	310,000
NsG-189	University of Maryland Conduct behavioral research and experimental analysis of complex behavioral repertories under full environmental control.	J. D. Findley	413,375
NASr-72	Operations Research, Inc. Conduct experimental studies by which human physiological responses during periods of space flight weightlessness may be quantitatively predicted.	Barry G. King	7,522
NASr-57	RIAS (Division of the Martin Co.) Conduct research on optimal statistical filters, including theoretical studies of the numerical accuracy and reliability of the Automatic Synthesis Program for optimal filters.	R. E. Kalman	24,673
R-35	U.S. Army Chemical Corps Biological Labs Research to determine the effects of ethylene oxide on the sterilization of electronic components and other materials used in space vehicles; determine contaminants of spacecraft components and materials, search for sterilants for plastics and determine sterilization procedures.	Charles R. Phillips	30,000
R-38	U.S. Navy—Medical Research Institute Conduct research into basic physiological mechanisms which defend the human body against heat and cold, and to determine the extent and efficiency of energy transformations in the human body and in isolated body constituents at the molecular level.	T. H. Benzinger	62,000

State and grant or contract No.	Organization and purpose	Investigator	Amount
MASSACHUSETTS			
NASr-16	Allied Research Associates, Inc. Review of biological mechanisms for application to instrument design.		$4,980
NASr-47	Bolt, Beranek and Newman, Inc. Conduct research on vibration in complicated structures by energy methods, including analytical studies by statistical methods, exploratory experimental work, and initial formulation of a statistical theory.	Ira Dyer	36,921
NASr-58	Bolt, Beranek and Newman, Inc. Conduct research directed toward the establishment of criteria for evaluating the subjective noisiness of aircraft sounds.		98,990
NsG-31	Massachusetts Institute of Technology. Experimental investigation of the effect of sound impingement upon shear flows.	Erick Mollo-Christensen.	41,027
NsG-117	Massachusetts Institute of Technology. Research on mechanisms of alloy strengthening by fine particle dispersions, with particular emphasis on selective reduction of non-refractory oxides, stability of metal-metal oxide systems, and solid solution matrices in metal-metal oxide alloys.	Nicholas J. Grant	17,500
NsG-211	Massachusetts Institute of Technology. The detection and identification of organic matter by mass spectrometry.	Klaus Biemann	73,117
NsG-222	Massachusetts Institute of Technology. Studies of the isotopic and trace element composition of tektites, including consideration of tektite origin.	W. H. Pinson, Jr.	67,808
NsG-234	Massachusetts Institute of Technology. Venus radar systems investigations.	J. F. Reintjes	80,000
NASr-90	Technical Operations, Inc. Research on a modeling technique for simulating and evaluation communication satellite systems.		70,000
NASw-168	United Research Inc. Study of the relations of groups to the process of policy formation and public information within NASA.	D. V. d'Arbelof	3,050
MICHIGAN			
NsG-226	University of Detroit. Synthesis of porphine-like substances from simple precursors.	Anton Szutka	35,640
NASr-83	Henry Ford Hospital. Conduct an experimental investigation of variations of the electroneur-physiological correlates and task-performance under conditions of controlled stimuli.	Lorne D. Proctor	90,654
NsG-39	University of Michigan. Investigation of cavitation-erosion phenomena (Cont. of Naw-6550).	F. G. Hammitt	66,930
NsG-115	University of Michigan. Study of microwave, radio frequency and ionizing radiation interactions in solids.	Chihiro Kikuchi	49,885
NsG-181	University of Michigan. Conduct research on space-probe techniques for possible measurements of electromagnetic phenomena.	F. T. Haddock	89,100

State and grant or contract No.	Organization and purpose	Investigator	Amount
NsG-214	University of Michigan An investigation of the carcinogenic potential of radiation in space.	Claire J. Shellabarger	$29,456
NsG-225	University of Michigan Research on heavy alkali and alkaline earth elements in stony meteorites, including studies to determine their isotopic strontium abundance and to identify their potassium and calcium bearing minerals.	Paul W. Gast	16,543
NASr-54(01)	University of Michigan Conduct research on the temperature, pressure, and density of the earth's atmosphere by rocket probe techniques, including: (a) Analysis of data from 9 IGY rocket flights; (b) Collection and analysis of pitostatic pressure data from approximately 6 rocket probe flights at altitudes between 40 and 140 kilometers; (c) Collection and analysis of data from pressure gages and an electron temperature probe, etc.	L. H. Brace	175,000
NASw-138	University of Michigan The development of rocket instrumentation commenced under Contract NASw-4 for the measurement of atmospheric pressure, density, temperature and composition in the altitude region 100-200 kilometers. Test instrumentation and synoptic version of system in rockets fired at Wallops Island.	L. M. Jones	212,400
NASw-140	University of Michigan Research on advanced measuring techniques of atmospheric and surface phenomena using radiometers sensitive in the visible and near infrared regions of the spectrum.	F. L. Bartman	450,000
MINNESOTA			
NsG-183	Mankato State College The effect of x-irradiation on the web building activities of spiders.	I. Grotenhuis	2,440
NASr-11	University of Minnesota Research on the effects of earth satellite environment and launching stresses on biological metabolism, including ground-based studies, design and construction of instrumentation for satellite-borne studies, and analysis of the results of the flight experiment.	Allan H. Brown	32,330
MISSISSIPPI			
NsG-80	Mississippi State University Biochemical study of mixed culture algae prototypes in a closed ecological system.	R. G. Tischer	60,345
MISSOURI			
NASr-63(01)	Midwest Research Institute Explore the need and desirability of the universities in the states of Missouri, Oklahoma, Kansas, Arkansas, Iowa and Nebraska to participate more vigorously in the space program; to ascertain the future potential for growth and its particular requirements for strengthening faculties and facilities to meet that potential.	M. H. Thornton	28,360

State and grant or contract No.	Organization and purpose	Investigator	Amount
MISSOURI—con.			
NASr-63(02)	Midwest Research Institute (a) Conduct studies on the influence of surface coatings on exo-electron emission during fatigue, (b) conduct studies on the physical configuration and electrical characteristics of test samples with associated equipment, (c) monitoring fatigue damage by the solid-state electron collection device.	J. C. Grosskreutz	$40,000
NASr-63(03)	Midwest Research Institute Aid and encourage the industries of the states of Missouri, Oklahoma, Kansas, Arkansas, Iowa, and Nebraska to participate in space technology, in order that the industries will be strengthened by application of the technology, etc.	M. H. Thornton	191,185
NsG-185	Washington University A determination of some characteristics of high altitude primary cosmic radiation at low and/or southern latitudes.	M. W. Friedlander	96,537
NEW JERSEY			
NASw-117	Isomet Corporation Research on closed chemical systems for the reduction of carbon dioxide to oxygen and carbon.	W. Ruderman	262,150
NsG-69	Princeton University The use of television techniques with telescopes above the atmosphere.	M. Schwarzschild	400,000
NsG-99	Princeton University Nonlinear Aspects of Combustion Instability in Liquid Propellant Rocket Motors.	Luigi Crocco	262,000
NsG-200	Princeton University Conduct research on ignition, and combustion stability and efficiency, of solid propellants at low pressures.	Martin Summerfield	31,050
NEW MEXICO			
NsG-142	New Mexico State University Photographic patrol and study of the physical conditions on the moon and planets.	Clyde W. Tambough	9,130
R-36	U.S. Air Force—Special Weapons Center Conduct experimental studies of the biological significance of cosmic radiations, and devise techniques for measuring selected phenomena.	E. Lifton	225,000
NEW YORK			
NsG-197	City College of New York Theoretical investigations of particle orbits and radiation modification in gravitational fields, and high-density plasma oscillations.	Henry Semat	22,380
NsG-112	Columbia University Methods for determining blood flow through intact vessels of experimental animals under conditions of gravitational stress and in extraterrestrial space capsules.	Lawrence O'Neill	108,000
NsG-160	Columbia University Theoretical studies of the applicability of geophysical data and analytical methods to the investigation of planetary interiors, planetary atmospheres and interplanetary space.	Maurice Ewing	25,000

State and grant or contract No.	Organization and purpose	Investigator	Amount
NsG-164	Columbia University. Theoretical research on the properties and transformations of matter at temperatures above 1 billion degrees Kelvin, and on the interaction of solar particles with magnetic fields.	P. Kusch	$30,820
NASw-82	Columbia University. A lunar seismograph (development and analysis of lunar seismograph).	M. Ewing	120,000
NsG-116	Cornell University. Kinetics of chemical reactions in gases at high temperatures utilizing shock tube and other gas dynamic techniques.	S. H. Bauer	55,000
NsG-184	Cornell University. The magnetohydrostatics of the magnetosphere of the earth and problems in theory of orbits of space vehicles.	T. Gold	65,823
NsG-212	Cornell University. Experimental study of optical and electronic properties of alkali halides under vacuum ultraviolet radiation.	P. L. Hartman	10,000
NsG-166	New York University. Conduct theoretical research on physics and hydrodynamics of interplanetary plasma and stellar interiors.	Morris Kline	16,530
NsG-167	New York University. Theoretical research on cosmic rays, neutrons, and interplanetary plasma in the solar system.	Serge A. Korff	14,000
NsG-168	New York University. Conduct theoretical research on atmospheric circulation and rotary storm formation.	Abdul Abdullah	12,950
NsG-169	New York University. Conduct research on the energy loss of charged particles in plasmas and the excitation spectra of plasmas with density gradients.	Werner Brandt	14,010
NsG-217	New York University. A study of the quantum yields and reaction rates in nitric oxide photo-lysis as a function of pressure, of added nitrogen, of diluents, and of wavelengths.	H. Austin Taylor	50,000
NASr-78	Radiation Applications, Inc. Conduct research on radiation-induced plastic memory in polymers suitable for self-erecting space structures, including considerations of parametric properties and treatment of the material, and means for achieving restoration temperature in space.	George Odian	62,659
NsG-48	Rensselaer Polytechnic Institute. Investigation of the Properties of Gaseous Plasmas by Microwave Techniques.	E. H. Holt	120,000
NsG-158	Rensselaer Polytechnic Institute. Research in fundamental atom chemistry with applications to the chemistry of the upper atmosphere.	Paul Harteck	159,700
NASr-74	Republic Aviation Corp. Research directed toward the determination of relationships existing among sensory deprivation, pain, and personality variables.	F. B. Benjamin	21,263
NsG-162	University of Rochester. Conduct investigation of the abundance of helium isotopes and other selected nuclei in low-energy primary cosmic radiation.	M. F. Kaplon	5,700

State and grant or contract No.	Organization and purpose	Investigator	Amount
NEW YORK—con.			
NsG-209	University of Rochester Research on automatic remote detection of bacteria, including modification of detection device for chemical analysis of lunar and planetary surface materials (Cont. of NsG-19-59).	Wolf Vishniac	$15,155
NASr-14	University of Rochester Optical problems relating to an orbiting astronomical observatory.	Harold Steward	84,000
NASw-107	University of Rochester Development research on solid state photodetector and associated optical materials.	Harold S. Stewart	200,000
NsG-159	Syracuse University Conduct research on adhesions of metals in high vacuum.	D. V. Keller, Jr	5,000
NsG-227	Yeshiva University The application of statistical mechanics of non-equilibrium processes to astrophysics and the determination of Galactic mass distribution and gravitational potential.	L. F. Landowitz	22,300
NORTH CAROLINA			
NASw-59	University of North Carolina Development and use of a precision coincidence telescope for study of primary cosmic radiation.	E. D. Palmatier	3,864
OHIO			
R-43	Aerospace Medical Laboratory Study the cardiovascular-respiratory system reactions of man to acceleration of various directions and durations.	E. H. Wood	31,350
R-49	Aerospace Medical Laboratory Conduct a partial support of the development, construction, and operation of a 5-degree-of-freedom motion device which will simulate low-frequency random and angular oscillations to which man may be exposed in a space vehicle.	H. Von Gierke	120,000
NsG-198	Case Institute of Technology Conduct experimental and theoretical research in plasma dynamics.	Osman Mawardi	250,000
NASr-12	General Electric Co. Development of analytical methods for determination of oxygen in potassium metal.	H. Kirtchik	50,000
NsG-213	Ohio State University Theoretical and experimental analysis of the electromagnetic scattering and radiative properties of terrain, with emphasis of lunar-like surfaces (Cont. of JPL N-28111).	Curt Levis	50,000
NsG-44	Ohio State University Research Foundation Investigation of parameters affecting the initiation of detonation in gaseous mixtures (Cont. of NAw 6551).	L. E. Bollinger	59,609
OKLAHOMA			
NsG-205	Oklahoma State University Effects of NASA programs on regional economic development.	Richard W. Poole	10,800

State and grant or contract No.	Organization and purpose	Investigator	Amount
NASr-4	Oklahoma State University Development of a transistorized miniature 15-channel pulse-time telemeter transmitting set having performance characteristics comparable to the AN/DKT-7 telemeter equipment and compatibility with the AN/FKR-1 receiving equipment.		$33,000
NASr-7	Oklahoma State University An analytical and limited experimental study of the mechanisms of impact, penetration and light emission for micrometeorites on an aluminum-coated photomultiplier.	F. C. Todd	39,665
NASw-159	Oklahoma State University Instrumentation of a rocket experiment to determine polar conductivity.	R. F. Buck	2,815
PENNSYLVANIA			
NASr-79	Bartol Research Foundation (The Franklin Inst.) Conduct research to reduce and analyze heavy primary cosmic radiation data from the Explorer VII ionization chamber.	Martin A. Pomerantz	45,100
NASr-70	MSA Research Corp Conduct investigation of scientific principles and processes for the recovery of breathing oxygen by the simultaneous reduction of CO_2 expired by man with H_2O.	R. E. Shearer	65,928
NsG-182	Pennsylvania State University Conduct a study of the effect of weightlessness and of densely ionizing radiation on simple cells and cell systems.	Ernest C. Pollard	8,755
R-31	U.S. Navy—Air Material Center Conduct an investigation, including a 6-man, 14-day experiment under sea-level atmospheric conditions, of the engineering, physiological and psychological aspects of a closed circuit life support system, and will include evaluation of selected physico-chemical methods of environmental control.	Roland A. Bosee	37,700
R-40	U.S. Navy—Air Material Center Evaluate the various aspects of the closed circuit life support system under Apollo capsule atmospheric conditions. Evaluate decompression effects, including hazards, associated with environmental control system conditions.	Roland A. Bosee	39,950
TEXAS			
NsG-199	University of Houston Conduct research in gas chromatography, with particular emphasis on detector techniques.	James E. Lovelock	30,100
NASr-87	University of Texas Design, fabrication, and installation of a 16-foot parabolic reflector antenna.	Archie W. Straiton	370,000
NsG-210	University of Texas Southwestern Medical School Conduct research on the influence of gravity on unicellular organisms, and optimization of the ultraviolet flying-spot microscope for living cell observations.	P.O'B. Montgomery	33,430

State and grant or contract No.	Organization and purpose	Investigator	Amount
WASHINGTON			
NsG-188	University of Washington. Conduct a neurophysiological analysis of the mechanism of surgical anesthesia produced by transcranial application of electrical currents.	Arthur A. Ward	$15,270
WISCONSIN			
NsG-187	Lawrence College. Conduct literature search for accounts of a particular group of fireballs, the cyrillids.	Priscilla Mount	385
NASW-65	University of Wisconsin. Research work which is intended to result in the automatic reduction and analysis of data from meteorological satellites.	V. E. Suomi	200,000
DISTRICT OF COLUMBIA			
NsG-34	National Academy of Sciences. Participation in the Resident Research Associateships Program.		654,000
NsG-186	National Academy of Sciences. . . . . of U.S. participation in the Second International Congress of Radiation Research.	John S. Coleman	15,000
NsG-190	National Academy of Sciences. . . . . . . of a symposium on acceleration stress.	G. A. Derbyshire	11,850
NASr-62	National Academy of Sciences. Conduct the administration of the NASA International University Program.		85,000
R-33	National Science Foundation. Support of rockets and satellites sub-center of world data center A.		23,150
NsG-87	Smithsonian Institution. Optical satellite tracking program.	Fred L. Whipple	650,000 3,250,000
NsG-102	Smithsonian Institute. Support of the biosciences information exchange.		10,000
NsG-35	Society of Photographic Scientists. Conduct volunteer photographic tracking program.		37,000
R-44	Aerospace Medical Center. To provide support for the conduct of animal experiments pertinent to the analysis of the effects of various ionizing radiations on air crews, and study methods of diagnosis and prognosis in acute and chronic radiation.	J. E. Pickering	180,000
R-50	Aerospace Medical Center. Joint plan for the acquisition of essential data necessary for shield design (Cont. of NTF-134).	J. E. Pickering	2,000
R-41	Atomic Energy Commission. Conduct biological research with heavy ion beams.	Cornelius A. Tobias	430,000
R-46	Atomic Energy Commission. Determine the effects of continuous 3-dimensional rotation of the earth's gravitational, magnetic, and electrical field gradients on plant morphogenesis.	S. A. Gordon	25,000
R-34	U.S. Library of Congress. Prepare an annotated bibliography of approximately 400 items, with abstracts, on the biological effects of magnetic fields.	Arnold Jacobius	6,000

State and grant or contract No.	Organization and purpose	Investigator	Amount
R-6	U.S. National Bureau of Standards Experimental research on thermionic materials, including selection of materials, construction of apparatus, and preliminary measurements of vaporization and thermionic omission.	Alan D. Franklin	$50,000
R-30	U.S. National Bureau of Standards Conduct research on the electron content, distribution and temporal variation in the ionosphere by means of scintillations and Faraday rotation of satellite radio transmissions to spaced ground stations.		135,500
R-45	U.S. National Bureau of Standards Conduct research on the physical properties of hydrogen; techniques for determining engineering data on cryogenic fields; materials and design principles for cryogenic systems; and compilation of low temperature data from the literature.		330,000
R-51	U.S. National Bureau of Standards Conduct investigation of the mechanism of transition from laminar to turbulent flow in boundary layers in both subsonic and supersonic flows.	G. B. Schubauer	140,000
R-32	U.S. Navy—Office of Naval Research Partial support of the "Third International Symposium on Rarefied Gas Dynamics."	E. A. Brun	3,000
R-42	U.S. Navy—Office of Naval Research Provide partial support for the National Research Council Committee on Hearing and Bioacoustics and the National Research Council Committee on Vision.		12,500
FOREIGN			
NsG-157	University of Berne Conduct theoretical studies on the radioactive dating of the lunar surface.	Johannes Geiss	13,400
NASr-69	Carl Wilhelm Sem-Jacobsen Develop three 4-channel ERG amplifiers for bioelectrical monitoring of astronauts.	Carl Wilhelm Sem-Jacobs.	15,000
NsG-180	Coun. for International Organizations of Med. Sci. Conduct a symposium on the selective vulnerability of the central nervous system to hypoxemia.	John F. Delafresnaye	6,000
NASr-77	Observatorire De Meudon Research on sodium vapor experiments at Wallops Station, Va.	Jacques Emile Blamont.	4,000

Appendix G

R and D Contracts or Amendments Thereto of $25,000 and Over Shown by Program

(Awarded April 1, through Dec. 31, 1961)[1]

[1] Footnote 2, p. 224 of NASA's Fifth Semiannual Report to Congress, indicated that contracts awarded between Apr. 1, 1961, and June 30, 1961, would be reported in this Sixth Semiannual Report. This information is now available in separate publications—Semiannual Procurement Action Reports and Annual Procurement Reports—obtainable on request from the Procurement and Supply Division, National Aeronautics and Space Administration, Washington 25, D.C. Consequently, the data on R&D contracts will not be repeated here nor in the Agency's future Semiannual Reports to the Congress.

U.S. GOVERNMENT PRINTING OFFICE: 1962 O—656299

National Aeronautics and
Space Administration
WASHINGTON 25, D.C.

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION